Publication No. 59
Instructional Material
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Instructional-cum-Practical Manual
for
Vocational Students

DOMESTIC APPLIANCES REPAIRER
(Principles of D.C. Circuits, Electromagnetism, and A.C. Circuits)

Contributors

R.N TIWARI	V.V. BELVI
V. DAMODARAN	B.B. PISE
G.G. BHISE	SURINDER KUMAR
V. HARINARAYANA SHARMA	S. RAY

A.P. VERMA

Experimental Edition
1984

विद्ययाऽमृतमश्नुते
एन सी ई आर टी
NCERT

Department of Vocationalization of Education
National Council of Educational Research and Training
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PREFACE

Ever since the introduction of vocationalization in our school system by several States in our country, the paucity of appropriate instructional materials has been felt as one of the major constraints in implementation of the programme and a source of great hardship to students offering vocational studies at the higher secondary stage.

The partment of Vocationalization of Education of the National Council of Educational Research and Training has started a modest programme of developing instructional materials of diverse types to fill up this void in all major areas of vocational education. The task is too gigantic to be completed by any single agency but the model materials being developed by us might provide guidance and impetus to the authors and agencies desiring to contribute in this area. These are based on the national guidelines developed by working group of experts constituted by NCERT.

The present manual is on ' [illegible] Appliances Repairer ' and is an important area in technology. It contains practical exercises to be performed by the students with simple steps to follow, precautions to be taken and data to be observed and recorded in observation sheet. Each experiment is complete with brief theoritical information, specific objectives, behavioural outcome, review questions etc. It is hoped that the students will find them immensely useful.

The pages that follow contain a draft of the writing which will be finalized after obtaining the responses and feed-back from students, teachers and others concerned. The materials will then be published in the printed form.

The users are requested to complete the questionnaire appended and return it to us. Comments and suggestions for improvement of the materials are also welcome.

The material has been developed by a group of experts as authors in a Workshop held at the NIE Campus, New Delhi. Their names are mentioned elsewhere and their contributions are admirably acknowledged. Shri A.P. Verma, Reader, V.E.U. deserves special thanks for editing and bringing the material in the present form. The assistance of all the staff members of Department of Vocationalization of Education, NCERT is also thankfully acknowledged.

New Delhi,
June, 1984.

(ARUN K. MISHRA
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INTRODUCTION

In basic appliances, the understanding of electrical circuits is very important. As a matter of fact all electrical appliances are the applications of various electrical and magnetic circuits. To note a few, a heater uses a heating element (the resistance of a certain wattage at 230 V) and the geyser also implies a heat sink element of large capacity. The transformer is a very useful device for converting the available supply voltage at consumer terminals, which is generally 230 Volts A.C. to 6 V. D.C. via a bridge AC - DC element (diode) for D.C. elements, like a transistor, charging of batteries etc. etc. Not only that, any other voltage can be obtained through the use of transformer, A division of current in any circuit can be controlled employing resistors, inductors or capacitors in series, parallel, or series parallel combination. The power in A.C. circuit depends directly on the type of load and the power factor depends upon the nature of load, i.e. inductive or capacitive. In any inductive load, the power factor is usually lagging whereas in a capacitive load it is of leading variety. The power factor control is very important from the point of view of undertaking supply of the electrical power as well as from the viewpoint of the consumer who has to pay more at low power factors.

All commercial applications require a three phase 400 volt supply to run 3 phase induction motors for milling or crushing or some such applications. Workshop lathes can be either run at 230 V or 400 V supply as the case may be. A refrigerator for domestic application uses a compressor motor at 230 V supply. Wide variations are generally not preferred and therefore the stabilisors are employed for providing a control to the supply voltage. An electrical iron also uses a heating element with a heat controlling device known as a thermostat. Domestic ovens and cooking ranges also employ heat sinks with thermostat as a controlling device. Therefore all such devices used in domestic applications require fitting of all elements (a resistor or inductor or the capacitor and winding/rewinding) with proper insulation coordination. To have a clear-cut understanding of the various domestic appliances and to understand the theory behind these appliances, the student needs to work in a laboratory on D.C. Circuits, electromagnetism and A.C. circuits.

For this purpose the laboratory on D.C. circuits, electromagnetism and A.C. circuits have been divided into three groups and each group contains six experiments. In each experiment the student is required to go through the specific objectives and theoretical background which is given for each experiment. The students should try to understand the circuit diagram before he makes an attempt to do the experiment. It is to be noted that each circuit diagram has two parts (series and parallel). Those components which are connected in series are ammeters, wattmeter current coil, resistors are known as components in series and those which are connected in parallel across the supply terminals are the volt meter and auto transformer, voltmeter, wattmeter pressure coil, loads are known as components in parallel. To check up the circuit the following points should be noted:

1. A student should make a check of all the components connected in series as well as their polarities, (specially in D.C. circuits).
2. Then he should check the components in parallel. The switches should be connected in the phase or the positive line.
3. He should also ensure the tightness of the connections. He should take instruments of proper ranges as shown in the circuit diagrams or the list of materials/components in each experiment.

He should ensure the completeness of the circuit, in all respects before he goes to switch on the supply.

The six experiments illustrated in D.C. circuits are pertaining to thestudy of the lead acid battery (i.e. constructional detail) and its voltage/Ampere hour capacity and verification of Ohm's Law and its application. Further the other experiments comprise the variation of positive and negative temperature co-efficients, studying series, parallel and series parallel circuits. In addition to the above, two experiment are kept for verification of thermal relations with calorimeter and detection and rectification of faults in D.C. circuits and finally an experiment is kept on the verification of Kirchhoff's Law with a star and delta equivalent connections.

Magnetic materials and electromagnets constitute an important area in the field of domestic appliances. Therefore the student must have a clear-cut understanding of different magnetic materials, construction of electro magnets using a D.C. source and also to know the application of electro-magnets like a bell, buzzer and a relay. Since the transformer constitutes a very useful application in our day-to-day life and has found a large scale application in a veriety of domestic applications, an experiment is designed on the study of the constructional details of transformer for a given design. The understanding of rotating magnetic field is very important for rotating electrical machines. The generation of electro-mechanical power, Motor or mechanical-electro power (generator) is based on such rotating magnetic fields. An experiment is kept for the understanding of such magnetic fields. Student will develop to know how and why these field are so useful for our domestic appliances.

These days the current trend is to go for A.C. voltage applications as it is directly available from the supply terminals and due to the easiness of handling various voltage levels through transformer, A.C. has found much more uses in contrast to the equipments working on D.C. Therefore, it becomes interesting to know the various features of A.C. voltage and current relations and its wave form, amplitude, frequency, power and power-factor. However, in D.C. circuits only resistance constitutes obstruction to the flow of current, the resistance, inductance as well as capacitors offer resistive impedance to the flow of A.C. currents. As stated earlier, the power and power flow in A.C. circuits also depend upon the impedences. For a clear understanding of the sinusoidal wave form, an experiment has been designed where a student may determine the amplitude, frequency and wave form on a C.R.O. Another experiment has been designed for drawing the vector diagrams for different resistance, inductance, capacitance, series R - L, R-C, R-L-C as well as their series, parallel and series parallel combinations. Here the students should ∠ exist distinguish the basic difference that ∠ in the voltage and current relations in contrast to D. C. circuits. The student is also required to obtain impedance for series parallel and series parallel A.C. circuits and check it with the experiment loading. This is to be done in experiment 15. Very interesting phenomenon known as resononce takes place in R.L.C. series and parallel circuits. Under resonance condition the inductive and capacitive reactances nullify and power transfer takes place through resistance. The students will be required to do this experiment for understanding the phenomenon in experiment 16. An experiment for Kirchoff's Law verifications in series, parallel and series parallel circuits is kept in A.C. circuits in a similar manner to that of D.C. Where as the addition is of algebraic nature in D.C., it is of vector variety in case of A.C. The students can compare experiments 6-17 and note its difference. Finally 3 phases 400 V star and delta connected circuits will be employed for studying voltage and current relations as well as the verification of relationship between line and phase values in voltage and currents through experiment.

This is to be noted that all domestic appliances are based on single phase supply and all commercial loads designed for 3 phase 400 volts. Therefore, it is expected that the students will find that these experiments form a basis in the understanding of domestic appliances from circuits point of view.

Experiment No. 1

1. Title of the experiment/Practical:

   To study lead acid battery, observe construction voltage and Ampere hour capacity.

2. Specific Objectives:

   i) To study the place of use and parts of lead acid battery.

   ii) Conducting different tests on battery with aid of cell tester and hydrometer

   iii) To study the points to maintain the battery.

3. Introductory Information and Related Theory:-

The use of a storage battery as a supplier of power is very common in society, specially in the field of Automobile.

The function of storage battery is to convert electrical energy into chemical energy during operation called as charging and re-converting chemical energy into electrical energy during the process known as discharging.

Thus a storage battery does not store electricity but it stores chemical energy.

The following points may be noted

a) The positive plate is lead Peroxide (PbO_2)

b) The negative plate is spongy lead

c) The container is of ebonite or hard rubber.

d) The plate grill is made of lead, Antimony alloy.

e) Electrolyte (H_2SO4) of specific gravity 1.250 is used.

f) Testing hydrometer indicating specific gravity of electrolyte (H_2SO4) is 1.3 at full charge condition.

g) Maximum charging rate is of 3-5 amperes

h) The cell voltage is 2.2. when fully charged.

i) The battery cell tester indicates the voltage on load.

j) Full charge condition on charging is indicated by milky colour of electrolyte due to gassing.

4. Equipments and materials.

- i) 6 volts lead acid battery
- ii) Hydrometer
- iii) Battery cell tester.

5. Circuit diagram.

(See in the diagrams sheet)

6. Procedures- The procedure contains the following points.

a) Study construction of the battery parts step by step

b) Prepare electrolyte of specified density step by step

c) Check specific gravity using hydrometer, it should be 1.250 - 1.3 as per manufacturers instructions.

d) Check and fill up battery by prepared electroyte.

e) Put the battery on charging as per diagram applying moderate charge

f) Check regularly every hour until fully charged

g) Observe and record readings every hour.

h) Remove the battery from charge after all the full charge indications.

7. Tabular Record:-

S.No	Plate colour	Condition	Tested voltage	Specific gravity

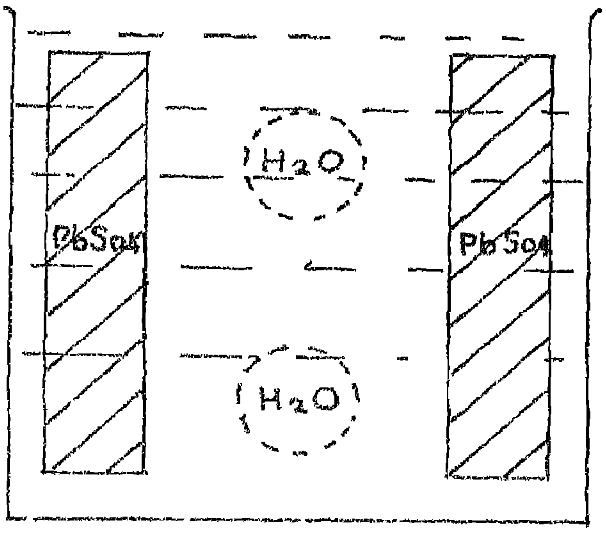


FIG 1.1
REPRESTING DISCHARGED
CONDITION OF THE BATTERY

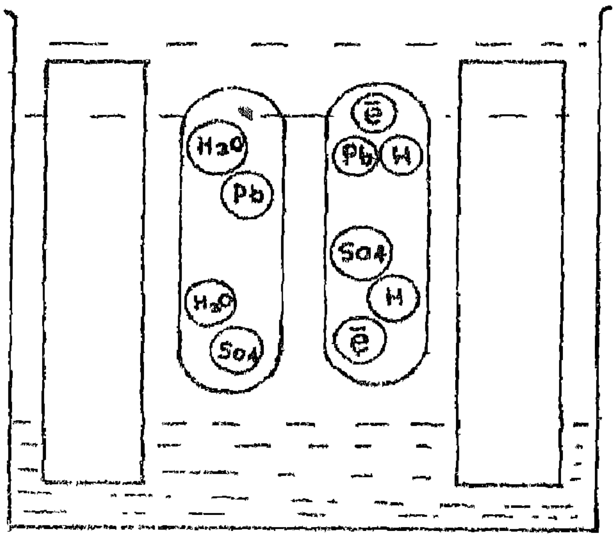


FIG 1.2
REPRESENTING THE REACTION

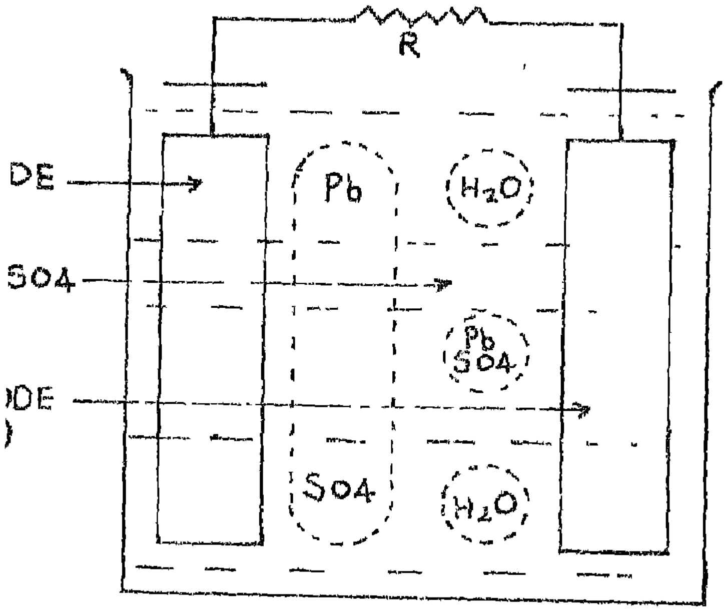


FIG.1.3
BATTERY IN FULLY CHRGED
CONDITION

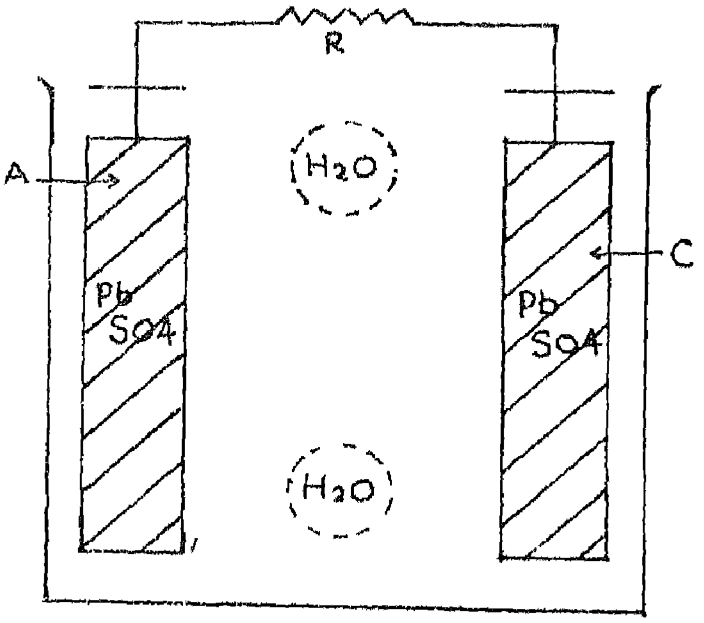


FIG.1.4
BATTERY IN FINAL CONDITION
OF DISCHARGE

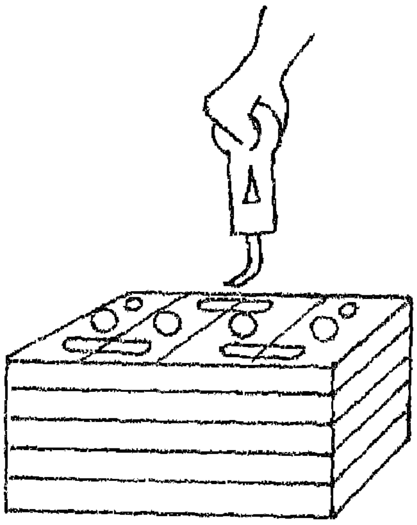


FIG.1.5
TESTING BY
HYDROMETER

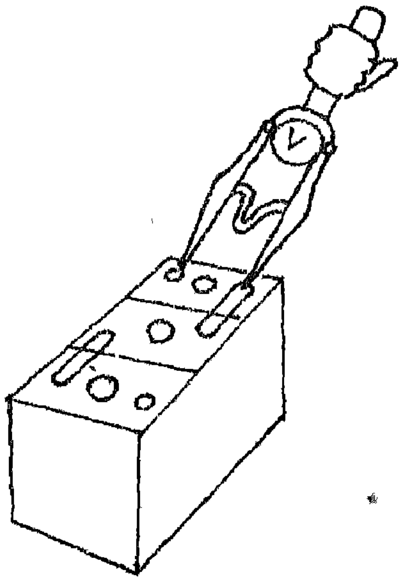


FIG.1.6
TESTING BY
CELL TESTER

8.- Precautions:-

a) Take care of the oil level in the battery.

b) Acid may spoil skin and clothing, so handle carefully.

c) Never over discharge battery

d) Charging should be done at moderate rate

9. Questions for evaluations:-

i) What is the specific gravity when the battery is fully charged?

fully ii) What is the /_ charged voltage per cell ?

iii) What should be the safe charging rate ?

10. References:-

i) Electrical Engineering with worked examples by S.L. Uppal. (Khanna Publishers, Nai Sarak, Delhi)

ii) Experiments in Electrical Engineering by M.K. Dalal.

iii) Electrical Technology by H. Cotton.

Experiment No: 2

Title of Experiment/Practical

Verification of Ohm's law and its application

Specific Objectives:

i) To be familiar with voltmeter, Ammeter connections and measure resistance, current, Voltage and power.

ii) To connect set up, to prove Ohm's law that current is directly proportional to applied voltage.

iii) To connect and test set up to prove Ohm's law that current varies inversely as resistance in circuit.

Introductory Information and Related Theory:

An electric pressure is measured in Volt-read by Voltmeter.
pere An electric current is measured in ∠ read by Ammeter.
The opposition to the flow of electric current is the resistance measured in Ohms by Ohmmeter, wheat stone bridge or Volt-Ammeter method. Power is the product of Volt-Amps, and is measured in Watts- by wattmeter.

The Ohm's law gives relation between current, pressure and resistance. It states that current in a given circuit at an invariable Temperature is DIRECTLY Proportional to the PRESSURE in volts and INVERSELY Proportional to the RESISTANCE in Ohms, provided other physical conditions are maintained constant.

Equipments and Materials:

6G. Dry Cells 8 Nos.

Voltmeter M.C. 0-15V

Ammeter M.C. 0-500mA

Resistor 25 ohm/10W=4Nos.

To ls block = 1

Connecting wires=12Nos

variable rheostat0-25 ohm

Circuit Diagrams:- See diagram 2.1, 2.2 and 2.3 attached

Procedure:

1. Wire up, connect set up as per diagram 2.1 for measurement of current, voltage, power and resistance.

2. Put on the switch and observe volt-ammeter readings & record.

3. Repeat twice changing resistance value and record observations.

4. Calculate resistance and power using formula R=E/I, and W=EI Where as E=Voltage, I=Current and R=Resistance, W=Power in watts.

5. Wire up, connect set up as per circuit diagram 2.2 to prove Ohm's law step one.

6. Put on the switch and observe Volt-Ammeter readings, and record the observations.

7. Repeat above procedure by changing no of Cells-i.e. voltage, Record the observations step by step.

8. Wire up, connect set up as per circuit diagram 2.3 to prove second step of Ohm's law.

9. Put on the switch and observe Volt-Ammeter-Readings; record the observations.

10. Repeat the above procedure by changing no of resistors i.e. 1,2,3 and 4 in series step by step.

Record the observations step by step.

Tabular record of observation

Resistance	Current	Voltage	Power	Resistance	Current	Voltage	Resul

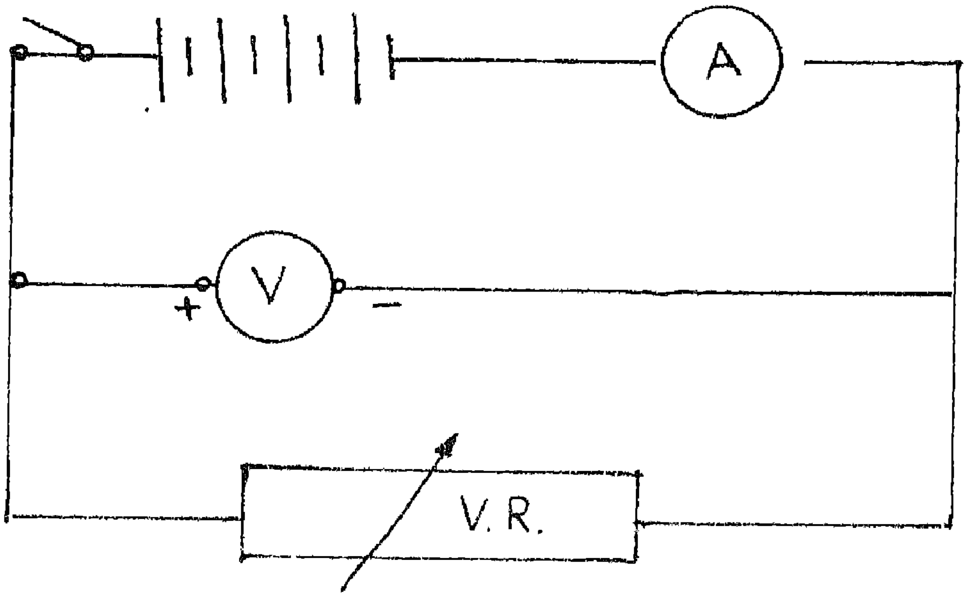


FIG. 2.1

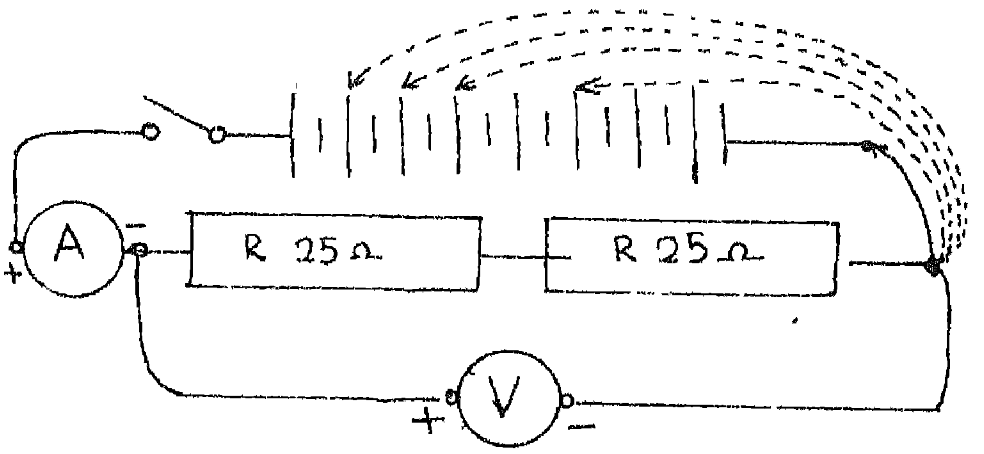
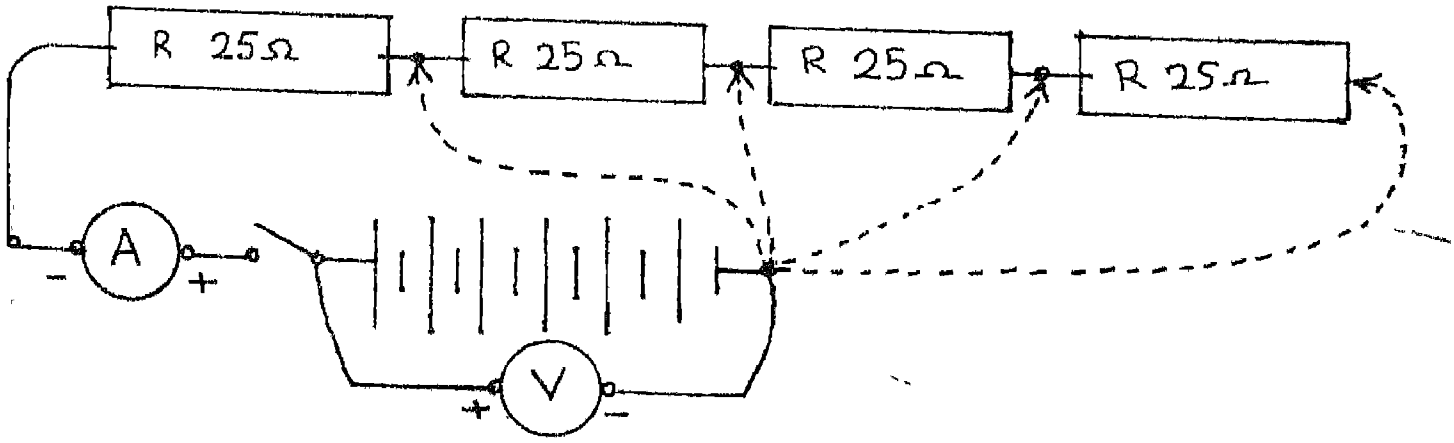


FIG. 2.2



CIRCUIT DIAGRAMS

FIG. 2.3

Precautions:

1. Do not keep switch 'ON' for longer time, that may drain and damage cells.
2. Select proper range, type of Voltmeter and Ammeter.
3. Connect Voltmeter across load and source of supply.
4. Connect Ammeter in series with the load.
5. Connect set up as per diagram and tighten the leads.

QUESTIONS FOR EVALUATION:

i) Current varies. .... as voltage (Directly/inversely)

ii) Increasing the resistance of circuit........... the current (increases/decreases)

iii) Ammeter is connected in series with the load and supply Becasuse (a) Ammeter has high resistance value, (b) low resistance value, (c) No resistance.

iv) Why is the voltmeter connected across load and supply ?

REFERENCES:

1. Electrical Technology by H. Cotton (London)
2. Basic Electricity D.C. Fundamentals by Duff(USA)
3. Principles of Electricity-illustrated of By Roy C.Norris (London)

Experiment No. 3

Title of Experiment/Practical

Verification of Positive & Negative Temperature Coefficients of Resistances.

Specific Objectives:

i) To learn to find positive temperature coefficient of metallic resistances.

ii) To be familiar with negative temperature coefficient of resistances like carbon.

iii) To learn measuring hot & cold resistance of lamp, and thermistor.

Introductory Information and Related theory.

Metals do increase in their resistivity if heated and it is called positive temperature coefficient of the metal

e.g. Tungsten = 0.0045/°C at 0°C. Copper 0.0039/°C at 0°C
Nichrome 0.0015/°C at 0°C (negligible)

Manganin - constantan = least of all i.e. 0.0000 /C/

Carbon and electrolyte, decrease in their resistivity if heated And the proportion of decrease in resistance as per increase in temperature is termed as Negative temperature coefficient, e.g. 0.0005/°C at 20°C per °C fall in temperature the thermistors are the devices quite small in size lesser than a centimeter in length designed for temperature range from below 0°C to above 200°C and can withstand mechanical and electrical stresses. These are used as safety controls in electrical motor winding against heating and other dangers.

Equipment and Materials.

Carbon filament lamp=one (240v/100w) = one

gas filled metal filament lamp (240v/100w) = one

Thermistor (of any available type) one.

voltmeter 0-15v-150v-300v dc = One

Ammeter 0-1Amp One.

Holder bakelite B.C. = 2 Nos.

Wire leads = 10 nos D.C. source 12v & 220 volts

Circuit diagrams: Fig No. 3.1, 3.2, and 3.3. attached.

Procedure

1. Connect lamp circuit with metal filament gas filled lamp, and Ammeter, voltmeter as per circuit diagram 3.1.
2. Apply d.c. 12 volt supply to the lamp circuit and measure current and voltage, and record observations.
3. Calculate the cold resistance of lamp using formula R=E/I whereas E=low voltage to 240 V lamp and I= current Record the calculated cold resistance value. (cold resistance can also be measured by multimeter ohmeter, wheatstone bridge, bridge megger.)
4. Connected the same lamp-to the 220 V d.c. supply with ammeter in series and voltmeter across the lamp as shown in the figure 3.2.

   Record the volt-ammeter readings and calculate hot resistance by R=E/I whereas E=supply voltage i.e. 220 volts and I=indicated current.

5. Compare the resistance difference between hot & Cold. You may calculate temperature, resistance temperature coefficient i.e. hot or cold resistance, either one, by equation given below:-

$$\frac{R\,1}{R\,2} = \frac{R\,0\,(\,1+\pounds\ t1\,)}{R\,0\,(\,1+\pounds\ t2\,)}$$

t 1 = Cold temperature,
t 2 = Hot temperature at bright

Where

R 0 = Resistance at 0°C,

R 1 = Cold Resistance

R 2 = Hot Resistance

£ = temperature co-efficient

t 1 = Cold temperature

t 2 = hot temperature at bright light

6. Repeat operation 1 to 5 using any heater element or hot plate/stove electric, having tungston/nichrome wire.
Result : Resistance increases in proportion to the rise in temperature. Positive temperature coefficient.

7. Repeat operations 1 to 5 using v.f. carbon filament lam 100 W/240 V, using volt-ammeter as per circuit diagram(observe & record readings £=0.0005/oC/calculate Hot and cold resistance of carbon lamp.
Result : Resistance of carbon lamp decreases in proport to rise of temperature. Negative temperature coefficie

8. Observe & study thermistor as available. Study applications of thermistors.

Tabular record of observations:

Type of Lamp 'thermistor	Cold Test voltage	Hot Test voltage	Cold test current	Hot test current	Cold resistance	Hot resistance	
Gas filled metal filament lamp							
Vacuum field carbon filament							
Thermistor							
Thermistor							

Precautions :

1. Do not exceed 12 volts while testing for cold resistance.
2. Lamp must be bright hot, while performing hot resistance test.
3. Calculate hot and cold resistance values correctly using correct temperature coefficient.
4. Thermistors are delicate, use carefully.

Questions for evaluation:

1. Carbon has negative resistance temperature - coefficient. (True/False).

∠ of resistance

2. Manganin wire has very negligible temperature coefficient ∠ having sufficient specific resistance, hence used for shunts & multipliers of elect. instruments.

(True/False)

3. What are the uses of thermistors in industrial application ?

(Discuss with instructor if necessary).

4. Where are the carbon filament lamps used ? Why ?

References:-

1. American Electrician Hand book (U.S.A.)
2. Industrial Electricity by Naddon & Gelmin (U.S.A.)
3. Electical Machines (Part II) by B.L. Theraja. (Indian)

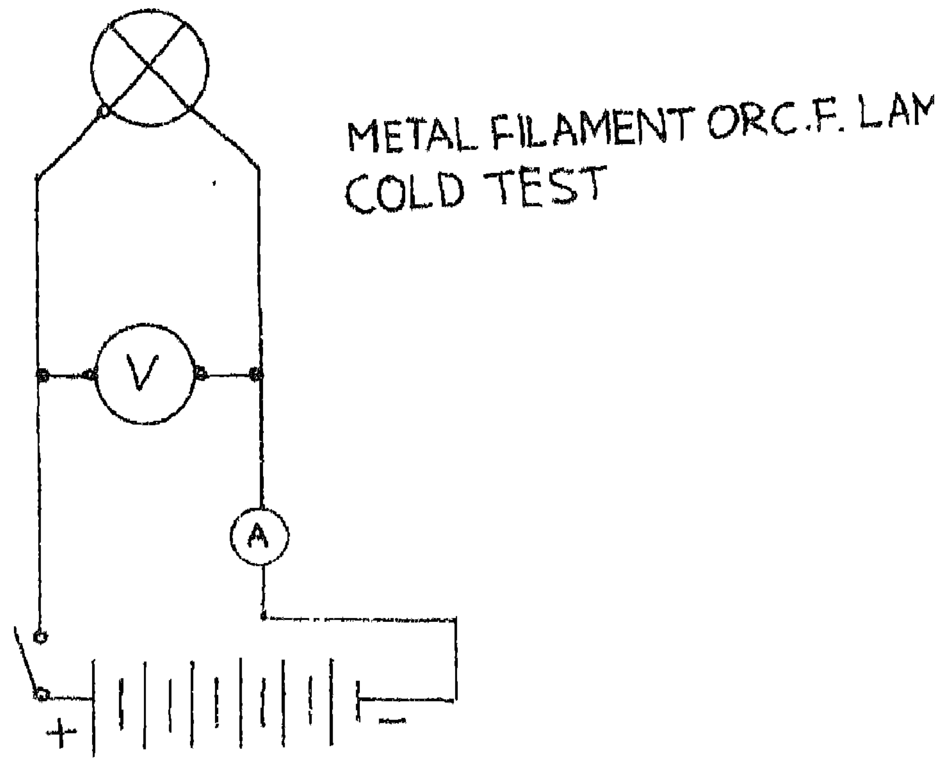


FIG. 3.1

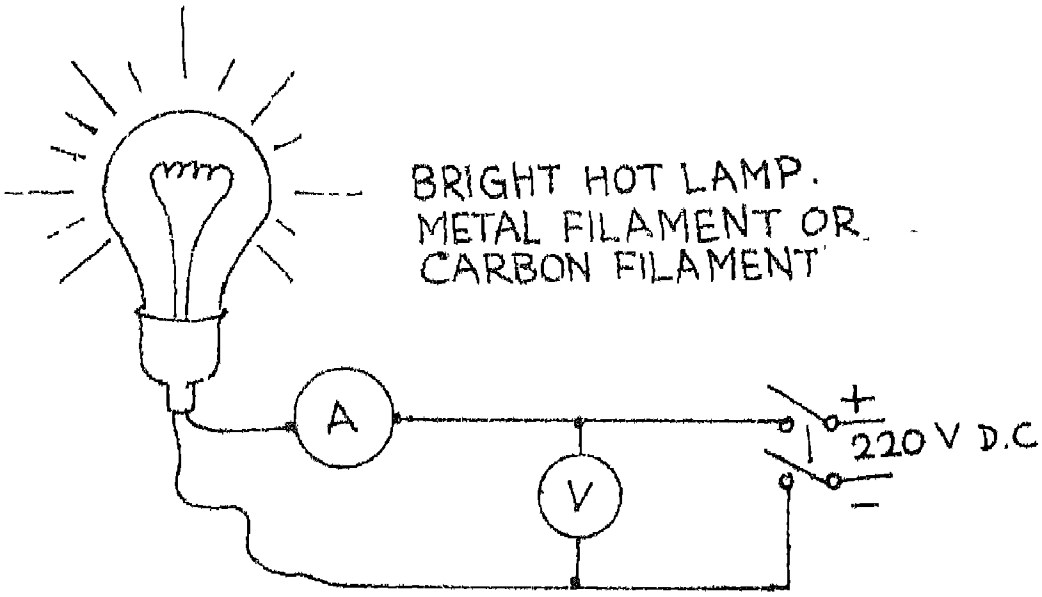


FIG. 3.2

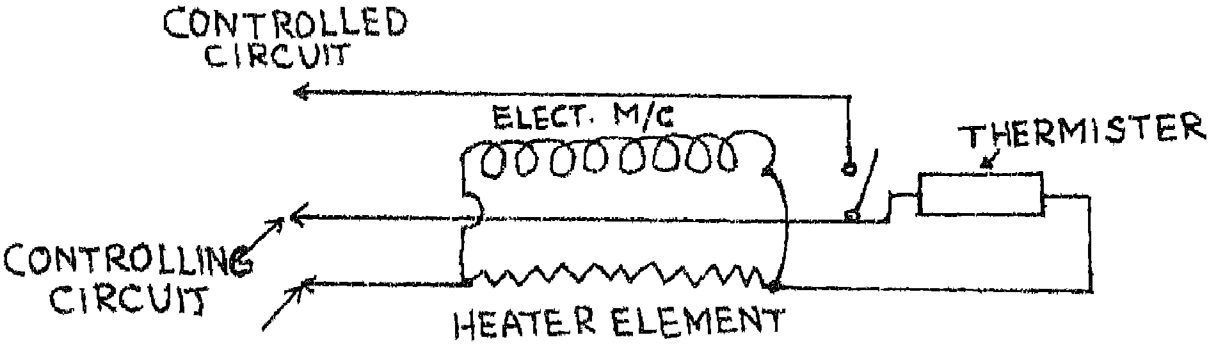


FIG. 3.3

Experiment No. 4

1. Title of Experiment/Practical. To study series, Parallel, and series - Parallel Circuits

2. Specific Objectives

   i) To learn to connect, test, series circuit and characteristics

   ii) To learn to connect, test Parallel circuit and characteristics

   iii) To learn to connect test series - Parallel circuit and characteristic.

3. Introductory Information and Related Theory :

In series circuit the current is same and the voltage is divided, the the resistance is greater than greatest resistance in series. In parallel circuit the voltage is same and the current is divided, the total resistance is less than the the least resistance in circuit.

In series circuit the connections are from positive to negative and the continuity of current is broken if the circuit is broken.

In Parallel circuit the connections are from positive to positive and negative to negative and if the continuity of current is broken at any branch the circuit current does not stop.

4. Equipment and Materials

a) Voltmeter (D. C.) 0.5...

b) Ammeter 0 - 1A

c) 12 V battery (lead acid type) Capacity 10 AH

d) Connecting leads

e) Vitreous type or carbon clay resistors of 100 ohms (LOW) - 6 Nos.

5. Circuit diagram:

(See deagrams 4.1, 4.2, 4.3 attached)

6. Procedures:-

(A) Connect resistors, voltmeter, and ammeter as shown in the figure 1.1. Observ and record Voltmeter, Ammeter readings. Calculate total resistance R by $R = \frac{V}{I}$

Result :- (1) Resistance $\overset{(R)}{\wedge}$ is directly added,
Voltage ∧ is distributed ∠ (V)
Current ∠ remains the same ∠ (I)

(B) Connect resistors in parallel and voltmeter and Ammeters as shown in the figure 4.$_2$ observe and record readings. Calculate total resistance by formula $\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$

Where R1, R2, R3 are resistances connected in parallel and R is the combined resistance of the circuit

Results:- Voltage remains the same and the current is divided. Total resistance is less than least resistance in circuit.

(C) Connect resistors as shown in the figure 4.3 and voltmeter alternately and step by step across each resistance. Observe and record the readings. Calculate current in each resistance $I = \frac{V}{R}$

Results:- Current is distributed in Parallel branches (Groups) but same in series grouping, and voltage is distributed in series groupings.

7 Tabular Record:

1) Series Circuit :- Total ∠ = R1 + R2 + R3

∠ Resistance

Total current = $I = \frac{E}{R}$

Voltage drop across R_1 = I x R1

S.No	Total Resistance	Current	Voltage R 1	drop across 2	R3	Total Voltage

2) Parallel Circuit

S.No	Total Resistance	Current	Voltage R 1	drop across R 2	R 3	Total Voltage

Calculations:-

The Resistance R =

Total Current - $I = \frac{E}{R}$

$I = \frac{E}{R_1}$

3) Series Parallel Combination.

S.No	Total Resi	Total Current	IR_1	IR_2	IR_3	IR_4	IR_5

Calculations:

Total Current = E/R

8. Precautions:- (1) Connect correctly as per the diagram (2) Do not keep loose connections (3) Do not drain the battery for long time.

9. Questions for evaluations: (1) What is a series circuit ? (2) What is a parallel circuit ? (3) How the voltmeter and ammeter / connected ?

/ are

10. References: (1) Experiments in Electrical Engineering by M.K. Dalal (2) A. C. And D.C. Fundamentals by B.L. Thereja

SERIES CIRCUIT

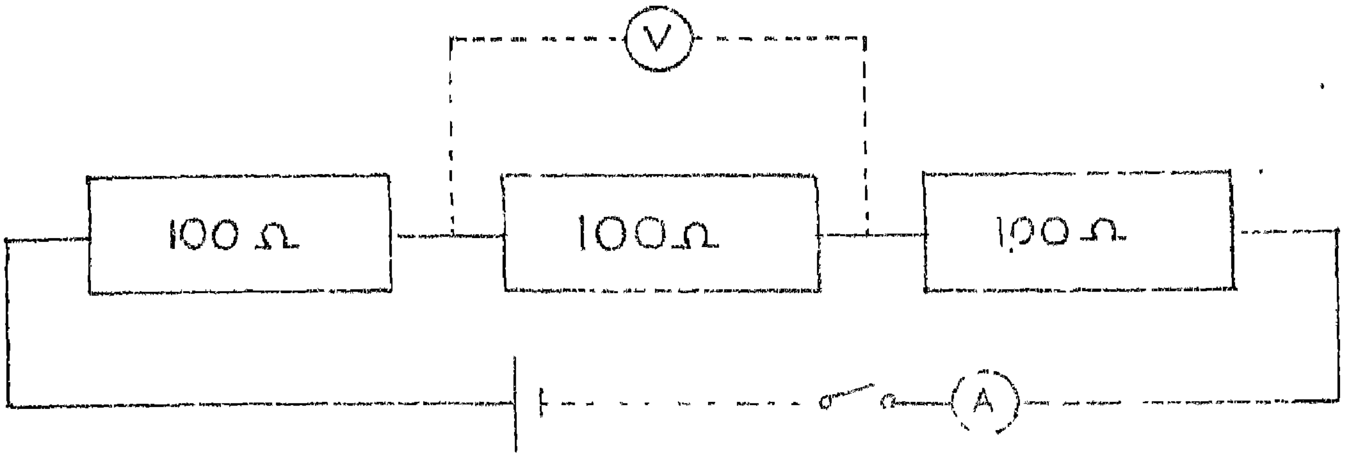


FIG 4.1

PARALLEL CIRCUIT

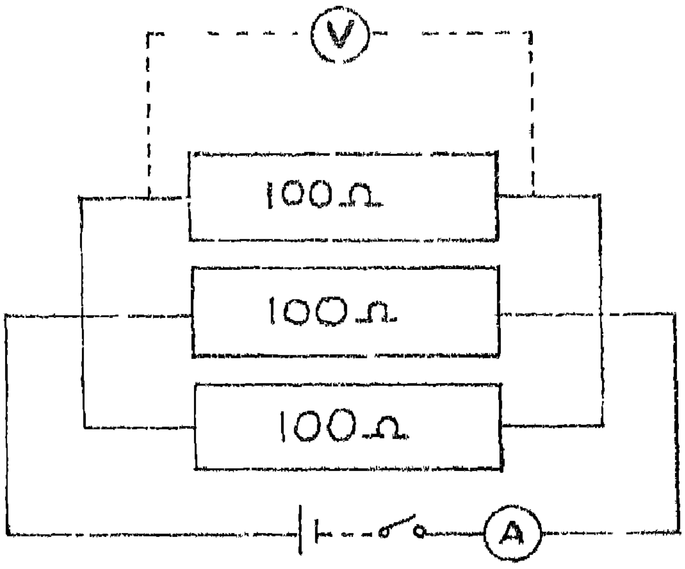


FIG 4.2

SERIES-PARALLEL CIRCUIT

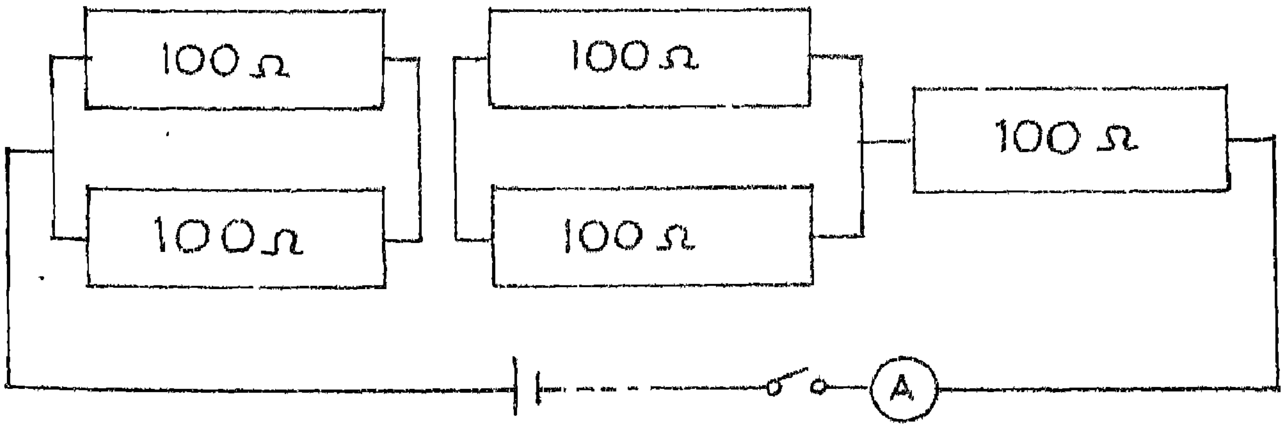


FIG 4.3

Experiment No. 5 a

1. Title of Experiment/Practical

   Verification of Thermal Relation with Calorimeter

2. Specific Objectives:

   i) To study construction of calorimeter

   ii) To learn to connect calorimeter for verification

   iii) To be familiar with Heat & Electrical energy relation and problems/calculation.

Introductory information & related theory:

Calorimeter is the device to measure heat in calories. Calorie is the unit in metric system for heat when one gramme of water increased (or decreased) to a temperature of 1°C. And one calorie is - equivalent to 0.24 joule i.e. watt second. British thermal unit is the heat required to raise (fall) the temperature of one pound of water to one $^\circ$F. One B.Th.Unit equals 1055 joules/watt second. All the heating appliances work on heating effect of electric current.

∠ or

Equipment & materials:

Calorimeter one d.c. source (Dry cells 6 G type = 4 Nos.)

thermometer, 0-360°C or as available.

connecting leads. voltmeter 0-7.5^{V}d.c. Ammeter 0-3Ad.

connecting leads = 12 Nos.

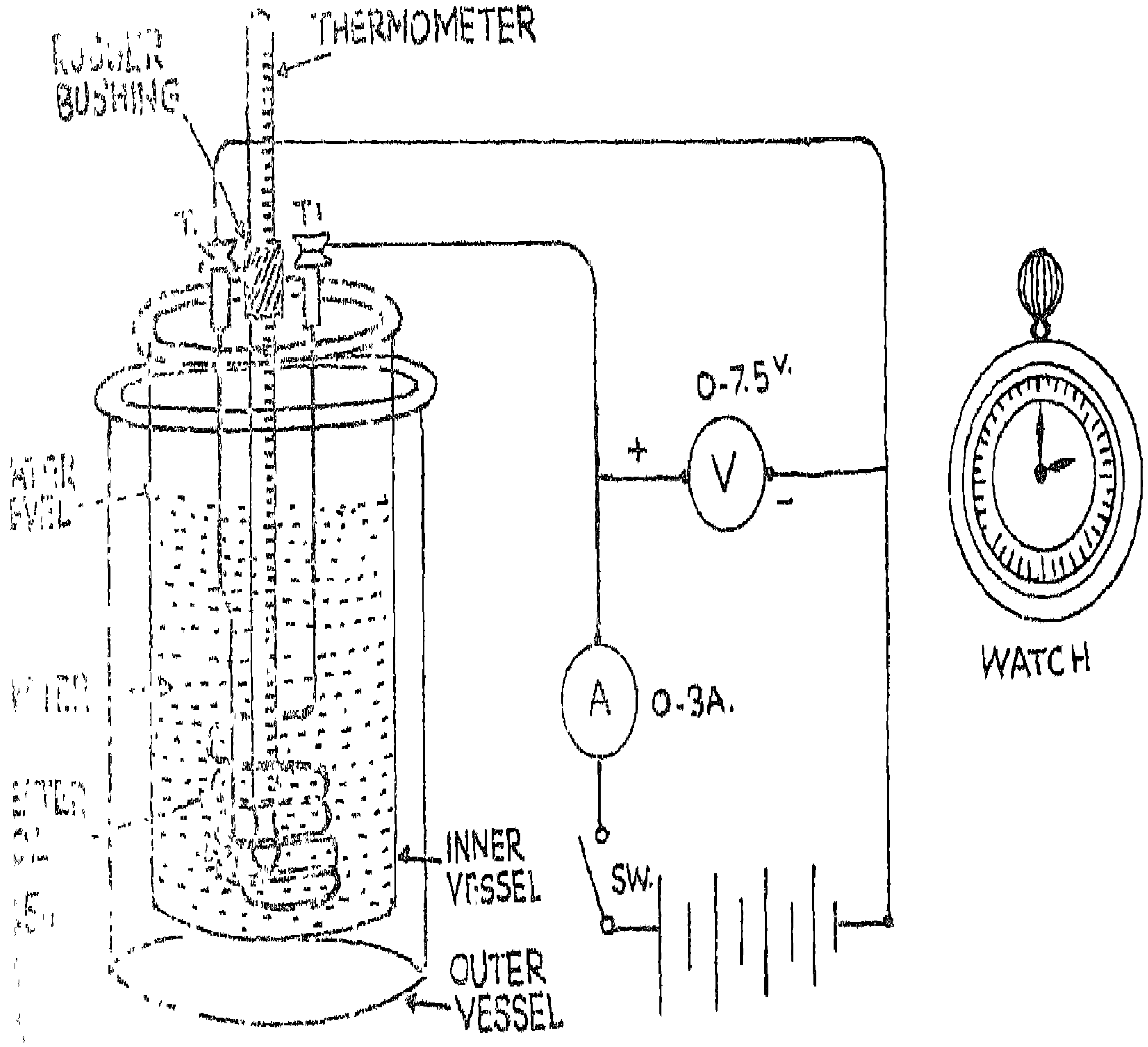
Circuit diagram (see diagrams attached)

Procedure:

1. Study calorimeter step by step. Outer container, inner vessel, heater element, terminals, Rubber bush, water level, enclosure etc.
2. Connect calorimeter set up as shown in the figure connect volt-ammeter and dry cells for 6 volts d.c. Push down thermometer through rubber bush hole with oil applied to thermometer for easy going. Keep the water to the level.
3. Put on supply and observe volt-ammeter readings and watch time.
4. Record observations and time. Stop after 5 minutes, and calculate joules by formulae Joules = I^2rt = V.I.T. where as v = applied voltage I = current passed, t = time in seconds.
5. Calculate calories = gms. sp. Heat. (T1-T2)°C where as gms wt. is the total equivalent weight of water & metallic containers and parts. sp. Heat = 1 for water, T1 = Starting normal temp. T2 = Temperature at completion of 5 minutes. Now v.i.t. = 4·1847 x calories and

   $$\text{efficiency } \% = \frac{4.1847 \times \text{calories}}{\text{volts. amps. Seconds}} \times 100 = \frac{4.2\ Q}{ws}$$

   Result: (4.1347 x calories) are equal to applied (v.i. time)
6. Repeat for 10 & 15 minutes of time.



WATER LEVEL - 300 gms

CONTAINERS EQUIVALENT WT. = 100 gms

CALORIE = gms x SP. H x $(T_1 \sim T_2)$

$$W = \frac{4.2\,w}{t.n}$$

CIRCUIT DIAGRAM

FIG. 5A.1

Tabular record of observation :

Total wgt. water equivalent	Volts	Current	Time	Temperature, C0.	Calories	Joules
gam 400	v 6		sec 300			
			sec 600			
			sec 900			

Precautions :

1. Fill up the water to the level only.
2. Do not apply excessive voltage.
3. Watch the time minutely as well as temperature.
4. Be aware of thermometer- it is glass & delicate.

Questions for evaluation :

1. What are the parts of calorimeter ?
2. What is relation between heat and electrical energy?
3. Joule is I^2 rt times, while 4.1847 times of calorie. (True/False)
4. Specific heat of water and metal containers is same (True/False)
5. Thermal efficiency equals the ratio of calorie output to the joule input. (True/False)

References :

1. Examples in electrical calculations by Admirality (England).
2. Industrial electricity by Naddon & Gelmine (U.S.A.)
3. Practical Electrical reference book, Odhams publication (London).

Experiment No. 5 b

1. Title of the experiment/practical: Detection and Rectification of faults in D.C. Circuit.

2. Specific Objectives:

   i) To learn to connect and check the continuity or open circuit test

   ii) To learn to connect and check short circuit test.

   iii) To learn to connect and check earth fault test.

3. Introductory information and related theory.: There ar
different types of faults that may occur in a D.C. Cir
The open circuit fault which may occur due to loose co
or by break in the conductor.

∠ to The short circuit fault which may occur due∠failu
of insulation of conductor.

The earth fault in which one of the bare wires ma
touch the body of the appliance.

Due to the above faults the working of the applia
in the circuit may stop. In case of earth fault the
appliance gives shock.

4. Equipment and material.

i)	6 volt battery	- 1 Number
ii)	6 volt lamp	- "
iii)	6 volt bell	- "
iv)	Bell push	- "
v)	Multimeter	- "
vi)	Wire Pieces	- 5 "

5. Circuit diagrams. See diagrams attached.

6. Procedure : (a) Connect battery, bell push, lamp and bell with wire as shown in figure 5 b.1 Operate the bell push and observe the working. Here if the lamp is dark the wiring is open and if the lamp is dim the wiring is O.K. and the bell rings.

(b) connect battery, bell push, lamp and bell, with wire as shown in the figure 5 b.2.

(2) Hear operate the bell push and observe the working. If the lamp is bright winding is short.

(3) Connect battery, bell push, lamp and the bell with wire as shown in the figure number 5b.3. Here operate the bell pusch and observe the working. Here if the lamp is dark insulation is O.K. and if the lamp is bright the insultation has failed.

7. Tabular Records:- (Refer Figures)

S.No.	Test	Lamp	Bell
1.	Open circuit	dark	does not work
2.	Short circuit	bright	does not work
3.	Grounding	bright	does not work

8. Precautions:- (a) Do not keep lose connections.

(b) leakage causes shocks and dangers. Always maintain high grade of insulations.

9. Questions for evaluation:-

i) What do you mean by open circuit fault ? and why it occurs ?

ii) What do you mean by short circuit fault ? and why it occurs ?

iii) What do you mean by earth circuit fault ? and why it occurs ?

10. References:- (i) Electrical Engineering with worked examples by S.L. Uppal.

(ii) Experiments in Electrical Engineering by M.K.Dat

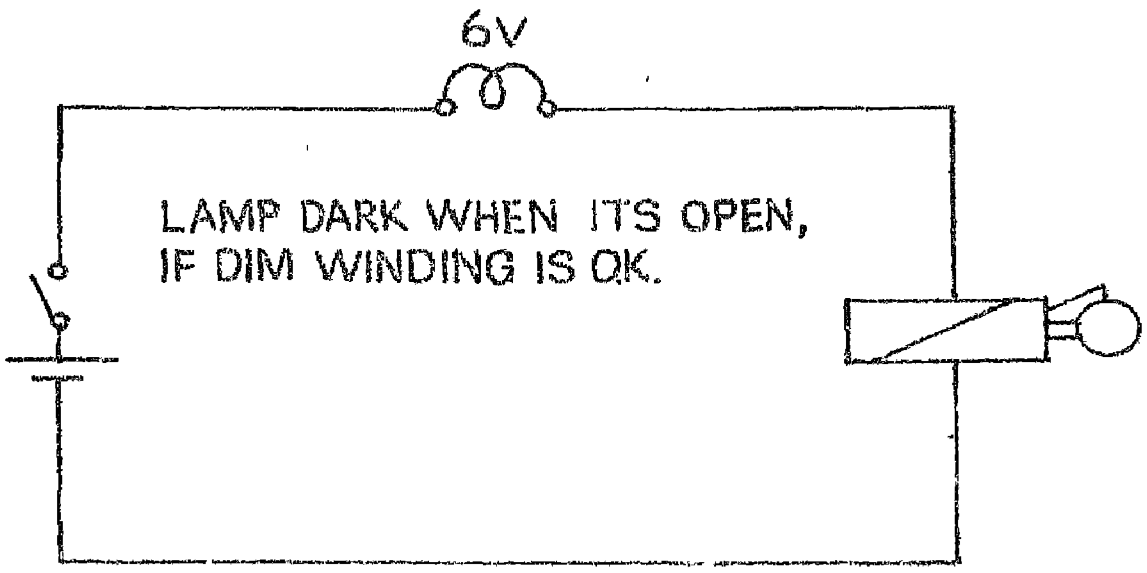


FIG 5b.1

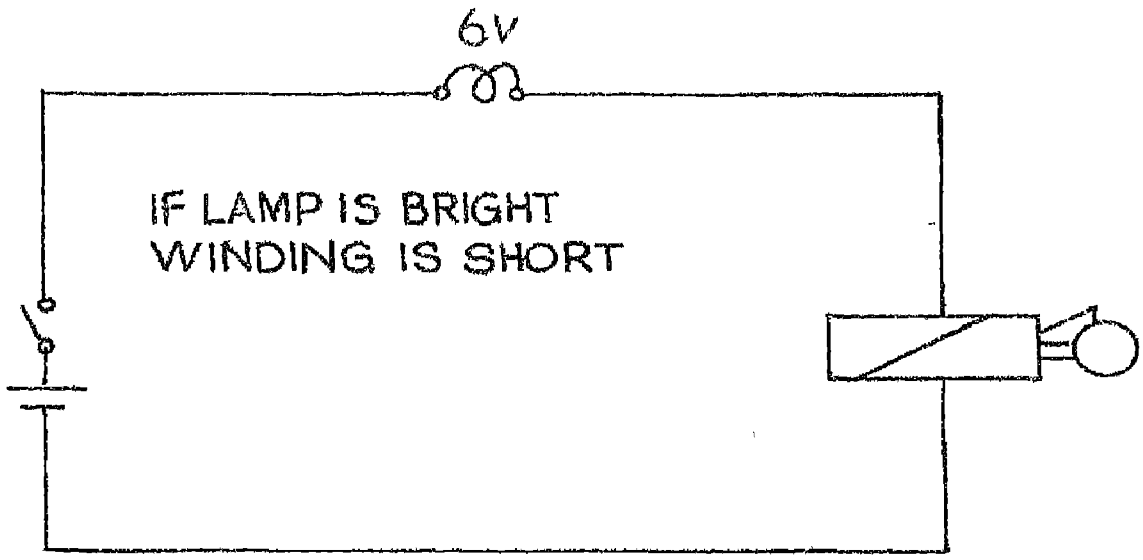


FIG 5b.2

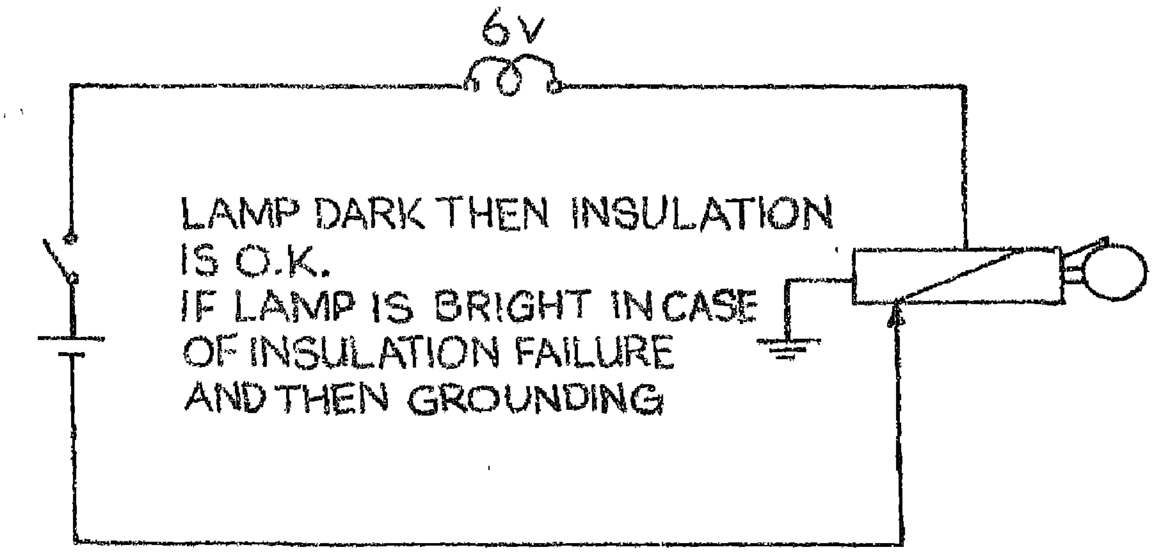


FIG. 5b3

Experiment No. 6

Title of Experiment/Practical

Prove Kirchhoff's Laws with star and Delta Equivalent connections.

Specific Objectives:

1. To learn to prove Kirchhoff's current law by star equivalent circuit.
2. To learn to prove Kirchhoff Voltage law by Delta equivalent circuit.
3. To be familiar with simple wheatstone bridge circuit to calculate unknown resistance.

Introductory Information and Related Theory:

Kirchhoff's "first law i.e., current law states that current flowing towards the Junction is equal to the current flowing away from junction. Algebraic sum of currents from all sides of junction is zero. The second law i.e. voltage law, states that the algebraic sum of voltages in a net work is zero. Applied voltage equals sum of voltage drops at individual resistors in line. The laws help to solve net work problems in practice and finding unknown resistance by Post Office box, slide wire bridge, wheat stone bridge, Bridge Megger, all based on Kirchhoff's laws.

Equipment & Materials:

1. Vitrious/carbon clay resistors = 10 ohm/ 10w, 20 Ohm/10 w, 50 Ohm/10 w,

2. Galvanometer 100 μA-0-100 μA = 20 Ohm/10 w,
3. Ammeter dc. 0-1A, = 2 Nos Voltmeters dc. 0-7.5 Volt
4. Ammeter dc.0-0.5.A = 2 Nos Connecting leads=15 Nos
5. Slide wire bridge. (Other bridges if available).
6. Dry cells 6 G type = 4 Nos

Circuit diagram:- (See diagrams attached)

Procedure:

1. Connect setup for star connection equivalent circuit as shown in figure 6.1.
2. Observe and record Ammeter readings.

   Recorded result shows that current in 50 Ohm resister is 0.105A, which is the sum of current in R20 Ohm i.e. 0.035A & I in R 10 Ohm i.e. 0.07A, and 0.07A, 0.035A-0.105=0 amp. ie
3. Connect set up of delta equivalent circuit as shown in figure 6.2
4. Observe and record voltmeter readings.
   Recorded result shows the applied voltage 6^V is the sum of voltage drops 4^V at 20 Ohm R and 2^V at 10 Ohm R and sum of voltage in Delta net work as per direc of current is zero. i.e. $+6^V - 4^V - 2^V = 0$ Volt
5. Connect slide wire bridge with galvanometer, known resister and unknown resister X' as shown in the figure 6.3 with two dry cells ∠ circuit.

∠ in

6. Slide over contact strip on resistance wire which is graduated on meter scale. Move until galvanometer indicates zero.

7. Observe & record left & right hand scales to the adjusted contact point (C.P.). Assume left side scale is R_I and right side scale is R_2.

8. Calculate Resistance value of unknown resistance 'X' by equation $\frac{R_1}{R_2} = \frac{R_3}{R_X}$ i.e. $RX = \frac{R2\ R3}{R_1}$.

   Record value of unknown resistance 'X'

9. Repeat 6,7 & 8 with another unknown resistances.

10. Study & observe construction of any one of the available instruments listed below:-

    (i) Bridge megger, (ii) Decade knob type wheat stone bridge, or (iii) Post office box type bridge.

    (II) Draw a sketch/circuit diagram of any one of the available (i) Slide wire bridge, (ii) Wheat stone bridge, (iii) Post Office box bridge, (iv) Bridge Megger.

Tabular record of observations:-

Current Voltage	50 Ohm resistance	20 Ohm resistance	10 Ohm resistance	Result
Current in STAR equivalent				Current flowing away from Junction equals current flowing towa Junction. Algebraic Sum of Voltages in Delta network as per Direction of current is Zero
Voltage in Delta equivalent				

Resistance scale R 1	Resistance scale R 2	Known Resistance	Formula equation $R_2 . R_3 / R_1$	Result of X Resistance
60 Ohm				
50 Ohm				
40 Ohm				
20 Ohm				

Precautions:-

1. Connect circuit as per diagrams correctly.
2. Galvanometer is very delicate & sensitive meter. carries micro ampere current only. Dont apply more than milli-volts and never directly.
3. Use milli ampere meters very carefully.
4. Calculate the results accurately.

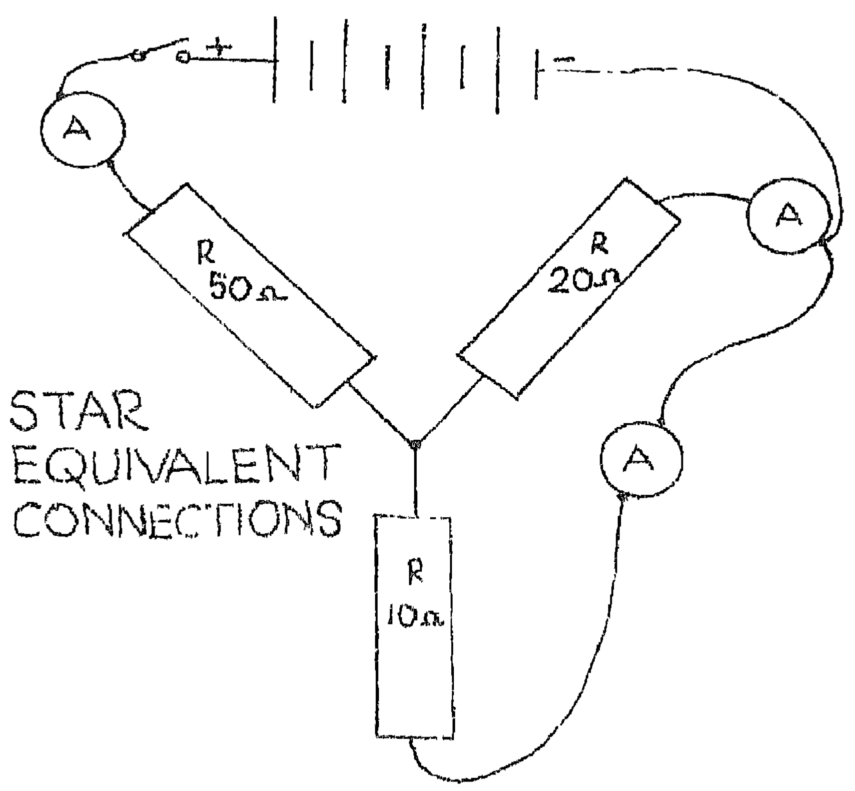


FIG. 6.1

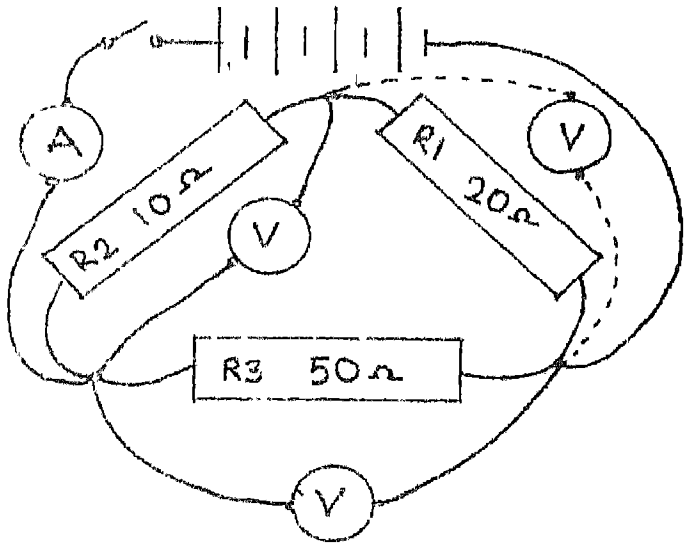
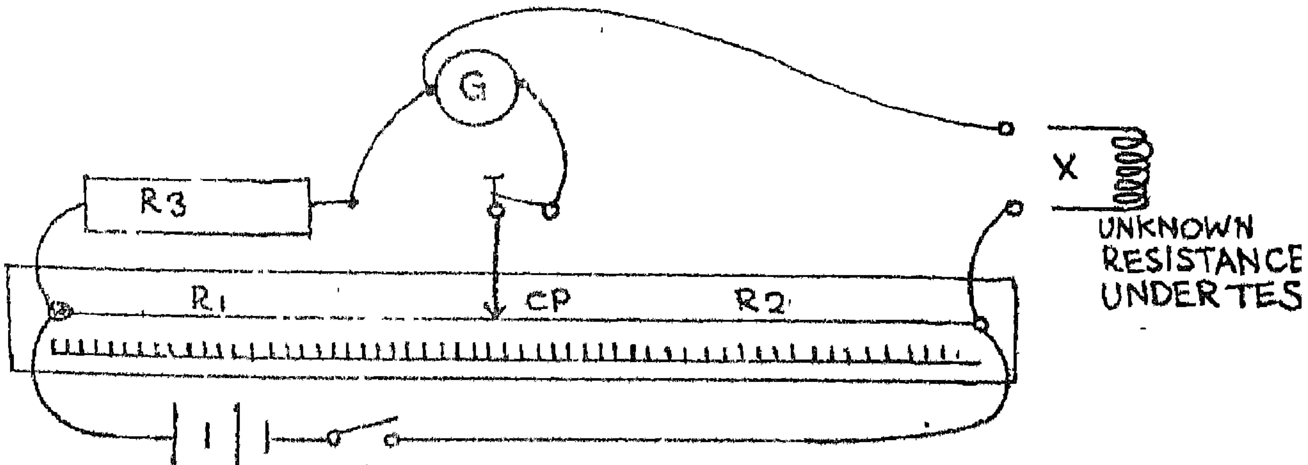


FIG. 6.2



SLIDE WIRE BRIDGE
CIRCUIT DIAGRAM

Questions for evaluation.

1. What is Kirchhoff's current law ?
2. What is Kirchhoff's voltage law ?
3. How will you use slide wire bridge to measure unknown resistance ?
4. Net work problems in practice are solved by Kirchhoff's laws.

(True/False)

References:-

1. Examples in electrical calculations by Admirality (British)
2. Electrical Technology by B.L. Theraja (Indian)
3. D.C. Fundamentals by Duff. (U.S.A.)

Experiment No. 7

1. Title of the experiment/Practical

To study different types of magnetic materials

2. Specific Objectives

To make the students familiar with the different types of magnetic materials used for different purposes in various electrical appliances and difference between their basic properties.

3. Introductory information and Related theory

Different magnetic materials being used in various electric devices can be grouped as under.

i) Magnetic materials used for making permanent magnets

The magnetic materials used for this class of magnets are generally cobalt steel chrome steel, tungsten steel and different grades of Alnico i.e. alloy of aluminimum, nickle, cobalt, copper and iron in different proportions. These materials have large coercivity and retentivity thus have large area of hystersis loop.

ii) Magnetic materials used for preparing Electromagnet

∠ are

Wrought iron and cast steel ∠ generally used in case of electromagnets. These materials have good retentivity but their coercivity is less as compar with the materials used for making permanent magnet

iii) Magnetic materials used for making transformer cores and armatures. Silicon sheet steel, Mumetal and Permalloy are the magnetic materials used for above purpose. Mumetal and Permalloy are very costly materials, therefore silicon sheet steel is generally used. These are low loss materials having small coercivity thus have small area of hystersis loop.

Hysteresis loop:-

If we take an iron piece and measure its flux density (B) when it is completely demagnetised and further measure flux density by increasing the values of magnetising force, the relation between these two quantities will be shown by curve O.A.C. This is called the magnetising curve. If the magnetising force is reduced flux density follows curve C.D., which shows that flux density does not reduce to zero when magnetising force has been reduced to zero. Flux density O.D. corresponding to zero value of magnetising force is called remanent flux density. Magnatising force O.E. is required to reduce the flux density to zero is called coercive force. Proceeding in a similar manner i.e. increasing the magnetising force in steps and then decreasing it to zero and again increasing in reverse direction, the closed curve CDEFG will be traced. This is known as hysteresis loop for the material (fig. 7.1)

Area of hysteresis loop represents the work done during a complete cycle of magnetization Hystresis loss for one complete cycle equals the area of hysteresis

∠Joules loop in ∠ /unit volume of the material.

Peak Value of magnetisation force. $Hm = \frac{N1.I.\sqrt{2}}{e}$

N_1 = No. of turns in main coil

I = Current in amps in the main coil

∠ path length L = Flux ∠ in metres

Hm £ I -(1)

Incluced e.m.f. in second coil, $V2=4.44\ f\ AB_m\ N_2$ Volts

where (r.m.s. value)

f- Frequency of supply

Bm - Peak value of flux density in the core

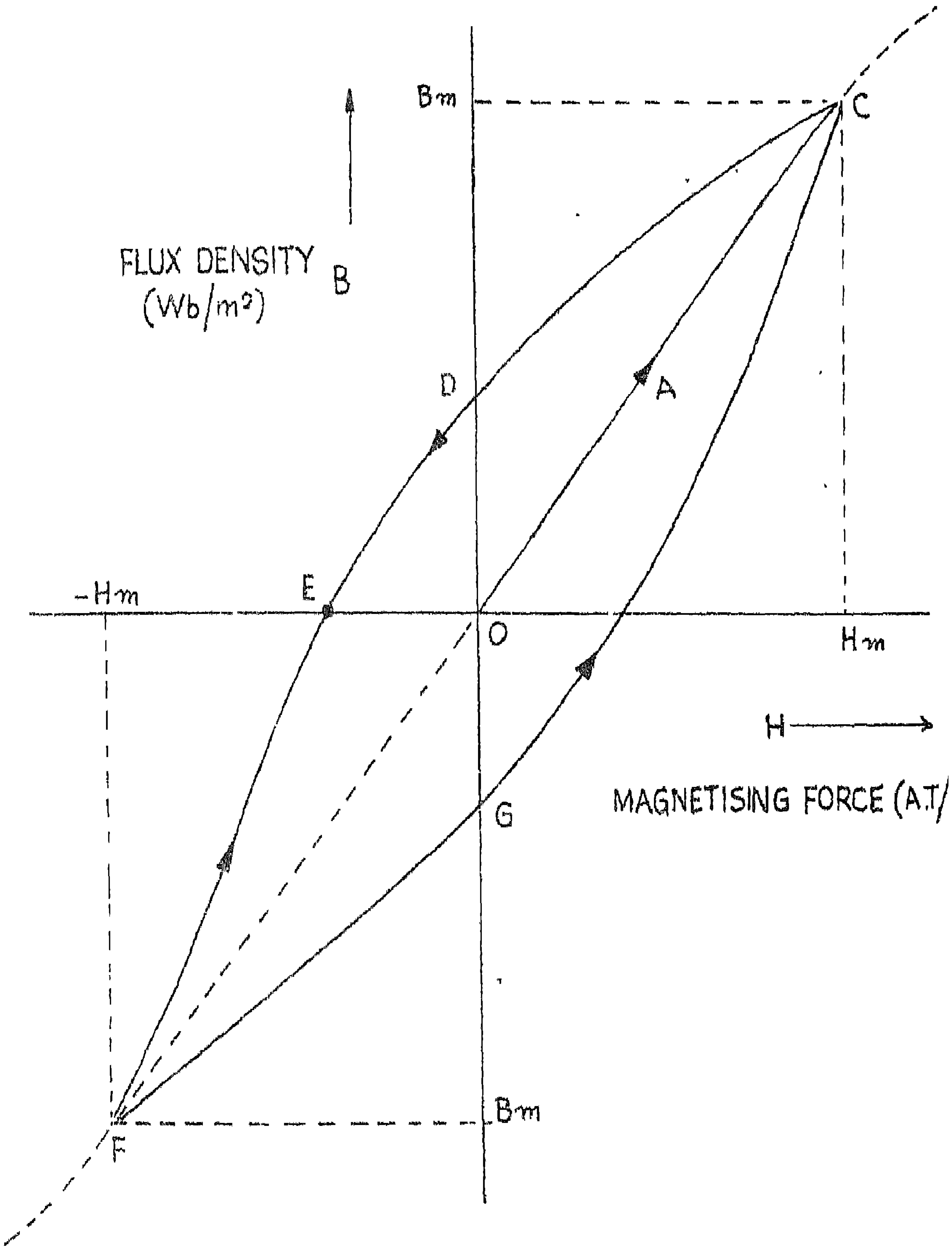
Bm £ V2 -(2)

To obtain B-H curve we make use of equation 1 and 2.

Relationship between B & h is

B = uH Where u= permeability of material

See figure 7.2. attached



OD = REMANENT FLUX DENSITY

OE = COERCIVE FORCE

FIG 7.1

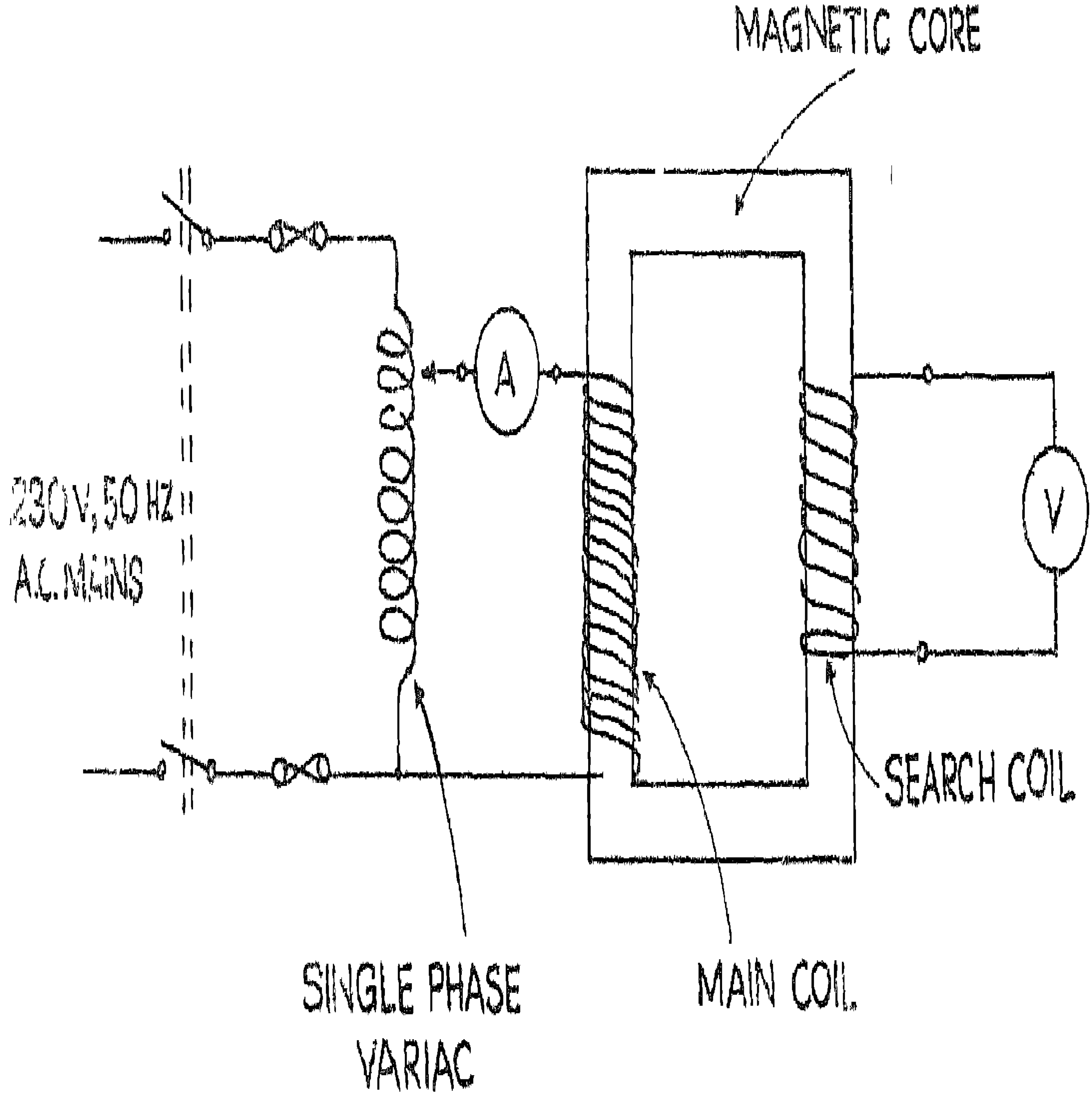

MAGNETIC CORE
230 V, 50 HZ
A.C. MAINS
A
V
SEARCH COIL
SINGLE PHASE
VARIAC
MAIN COIL

FIG 7.2

Observations

Name of Magnetic Materials	Their use	Properties	Hystersis loop area
Cobalt steel, Tungston Steel, chrome steel; Alinco	These materials are used for making permanent magnets.	These materials have large coercivity and retentivity	Area is large
Wrought iron, cast steel	These materials are used for making electromagnets.	These materials have good retentivity but their coercivity is small as compared to permanent magnets.	Area is smaller
Silicon steel, Mumetal, Permalloy	These materials are used for making transformer cores and armature.	These materials have small coercivity.	Area is very small.

Questions:-

1. What is the difference between an electromagnet and permanent magent ?
2. What materials are used for making transformer cores ?
3. What do you unsderstand by Hystersis losses?
4. How Hystersis loss is reduced in case of electrical machines ?
5. Explain the different classifications of magnetic materials ?

Experiment No. 8

1. **Title of Experiment/Practical**

   To prepare an Electromagnet with D. C. source.

2. **Specific Objectives**

   i) To prepare an Electromagnet with D. C. source

   ii) To see magnetic lines of force with iron filings.

   iii) To test the polarity

   iv) To change the polarity

3. **Introductory Information and related theory**

   When ever a piece of soft iron is placed in a current carrying coil, magnetism is induced in it and the piece of iron becomes an electromagnet. The polarity of electromagnet goes on changing in case of A.C. source where as it does not change in case when D.C. source is used.

   $$F = \frac{2\pi}{10} \frac{ni}{r} \text{ ergs.}$$

   Where

   F = Lines of force in ergs.

   $F \propto$ number of turns

   $F \propto$ strength of the current in amperes.

   $F \propto \frac{1}{r}$ radius of the coil in cms

4. **Equipment and Materials**

1.	S. E. copper wire	19 S. W. G.
2.	Lethriod paper	1 Piece
3.	Bolt with nut & washer	4"–½"

4.	Empire sleeve	1 Piece
5.	Lead acid battary	6v.
6.	Ampere Meter	M.C. type 0-5
7.	P.V.C. wire	7/22
8.	Iron filings	
9.	Variable resistance	5 amps 250 V
10.	Pencil, gum etc.	

5. Circuit diagram

See the diagram attached

6. Procedure

1. Insulate the bolt with the help of lethriod paper
2. Wind 'coil X' over insulated bolt with the help of winding wire in clockwise direction giving App. 180 turns.
3. Connect the D.C. source, Ampere meter and variable resistance as indicated in circuit diagram and pass current through the coil.
4. Test the polarity of electromagnet useing magnetic needle.
5. Reverse the direction of current, again test the polarity. It will be observed that by reversing the direction of current polarity of electomagnet is also changed.
6. Measure the attraction point by using a small piece of iron

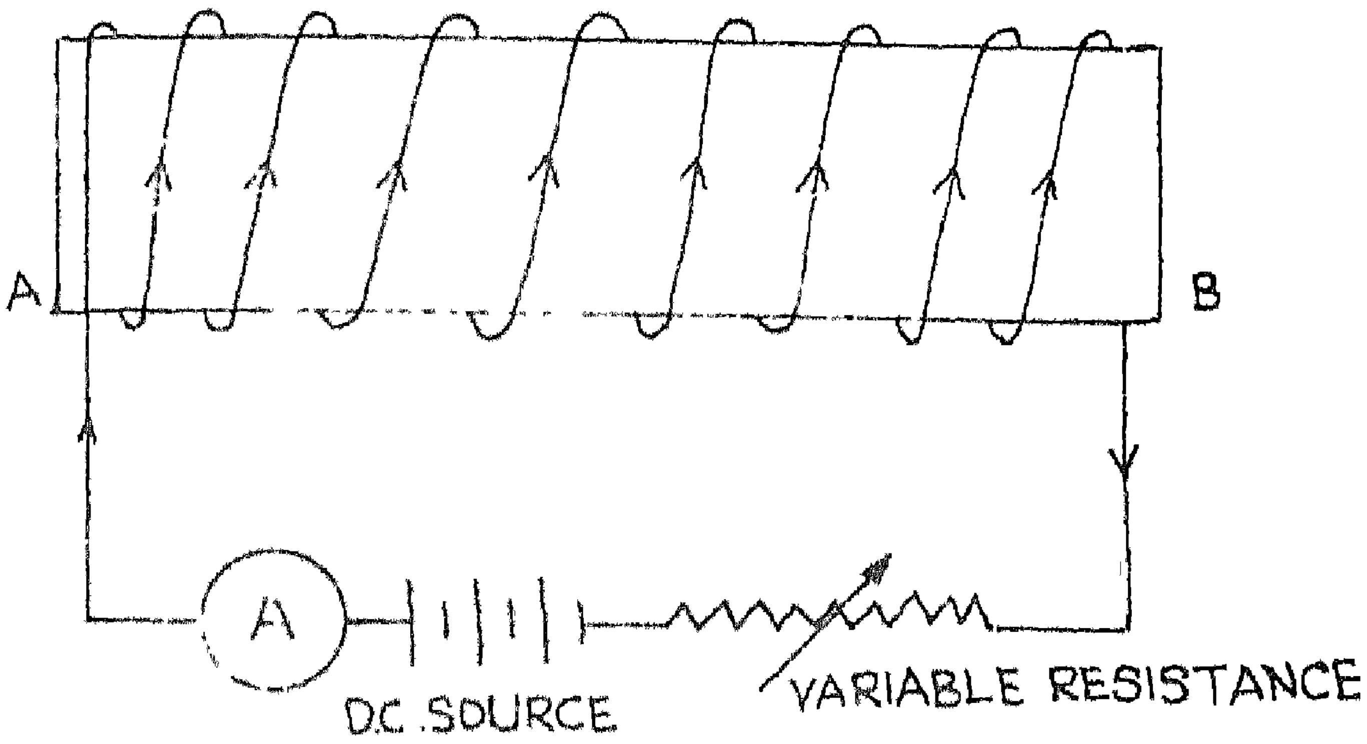
7. Now increase the number of turns of coil Y keeping current the same, measure the attraction points when number of turns is in-creased attraction point is in creased observe changes in magnetic field produced in each case by placing piece of paper on electromagnet and sprinkling iron filing on it.

7. Tabular Record of observations.

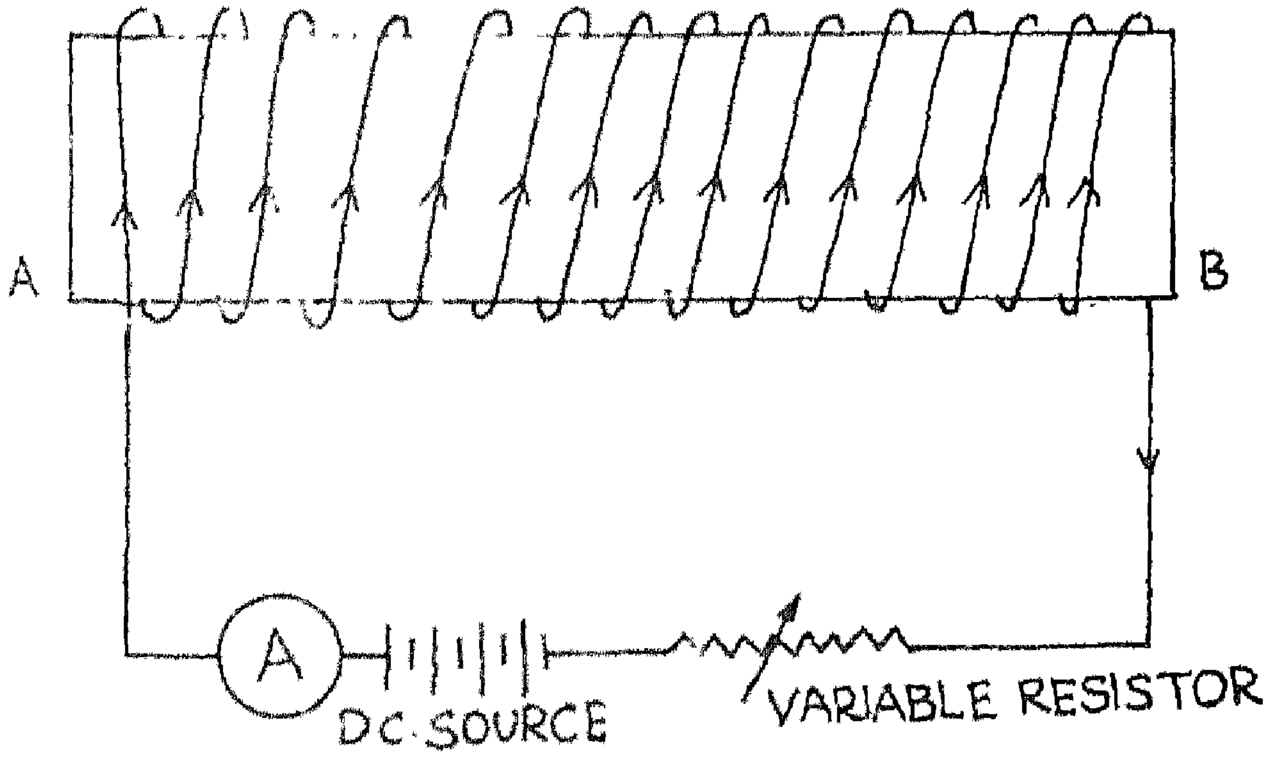
		A			B
No. of Turns	Current	Attraction point	Polarity at A	Polarity at A when direction of current is reversed	Place a piece of paper over electro-magnet & sprikle iron filing over it observe change in magnetic field in each case
Coil X					
Coil Y					

8. Precautions

1. Bolt should be properly insulated
2. There should be no twist or kink in winding wire.
3. Do not keep magnetic needle too close to the pole while testing polarity.



(COIL)X HAVING NO. OF TURNS N_1



(COIL)Y HAVING NO. OF TURNS N_2

CIRCUIT DIAGRAM

FIG.8.1

4. Increase the current in the coil gradually and electromagnet must be placed on a level surface.
5. The resistance introduced should be maximum at the begining to limit the current and it should be gradually reduced to pass required current though the coil.

9. Questions for evaluation

1. What happens when the direction of current in coil is reversed ?
2. What is the effect on attraction point when the current in the coil is increased ?
3. What is the effect on attraction point when number of turns in the coil are increased.
4. Why magnetism is procduced in a piece of iron kept in side a current carrying coil ?
5. Why the polarity of an electromagnet changes when A.C. source is used.

10. Refrances:

Electric domestic appliances by Bhatia.

Experiment No. 9

1. Title of Experiment/Practical

   To study the application of Electromagnet in the case o an Electric bell or relay

2. Specific Objectives

   To observe differnnt parts of an electric bell/Relay and to study the role of electromagnet in operation of electric bell/Relay.

3. Introduct any information and related theory

   Electric bell is a common electrical appliance used in offices, Guest Houses, Hotels and in domestic buildings. It is commanly used to call attendants. Electric bell has mainly following parts.

   1. Base plate - It is made of Bakelite and other parts are fitted on it.
   2. Magnetic coils - These coils are wound on coil formers using S.E. copper wire - and these are connected in such a way so as to produce different poles (North & South) in iron pieces placed at the centres of coil formers and these iron pieces are connected using on iron strip as shown in figure.
   3. Armature and striker - Armature is connected to soft iron core by means of steel spring. The distance between iron core and armature can be adjusted by means of adjusting screws. Striker is attached to

armature Sound is produced when striker strikes the gong.

4. Gong - It is small cycle bell shaped cup made up of steel fitted on base plate by means of iron strip. When push button is pressed the current complets its circuit through coils, armature and adjusting screw and soft iron core is magnetised and it attracts armature towards the poles of electromagnet and striker strikes the gong. When the armature is pulled by electromagnet electric circuit breaks and armature returns to its original position, again circuit is completed, armature is attracted by electromagnet striker strikes the gong. This process is repeated and bell produces sound.

Buzzer : The construction of buzzer is similar to an electric bell. It contains no gong and striker. Armature strikes the poles and produce sound.

4. Equipment & Materials

a) 1. Electric bell .
   2. Push button switch
   3. Connecting leads
   4. Screw driver

b) D.C. Motor starter

5. Circuit diagram: See diagram attached

6. Procedure:-

A) 1. Open the electric bell with help of screw driver and identify different parts.

2. Connect electric bell as per circuit diagram and observe its working by pressing push button.

B) Study the application and functioning of electromagnetic relay in D.C. motor-starter.

7. Tabular Record of observations :

1) Note down diffrent parts of an electric bell.

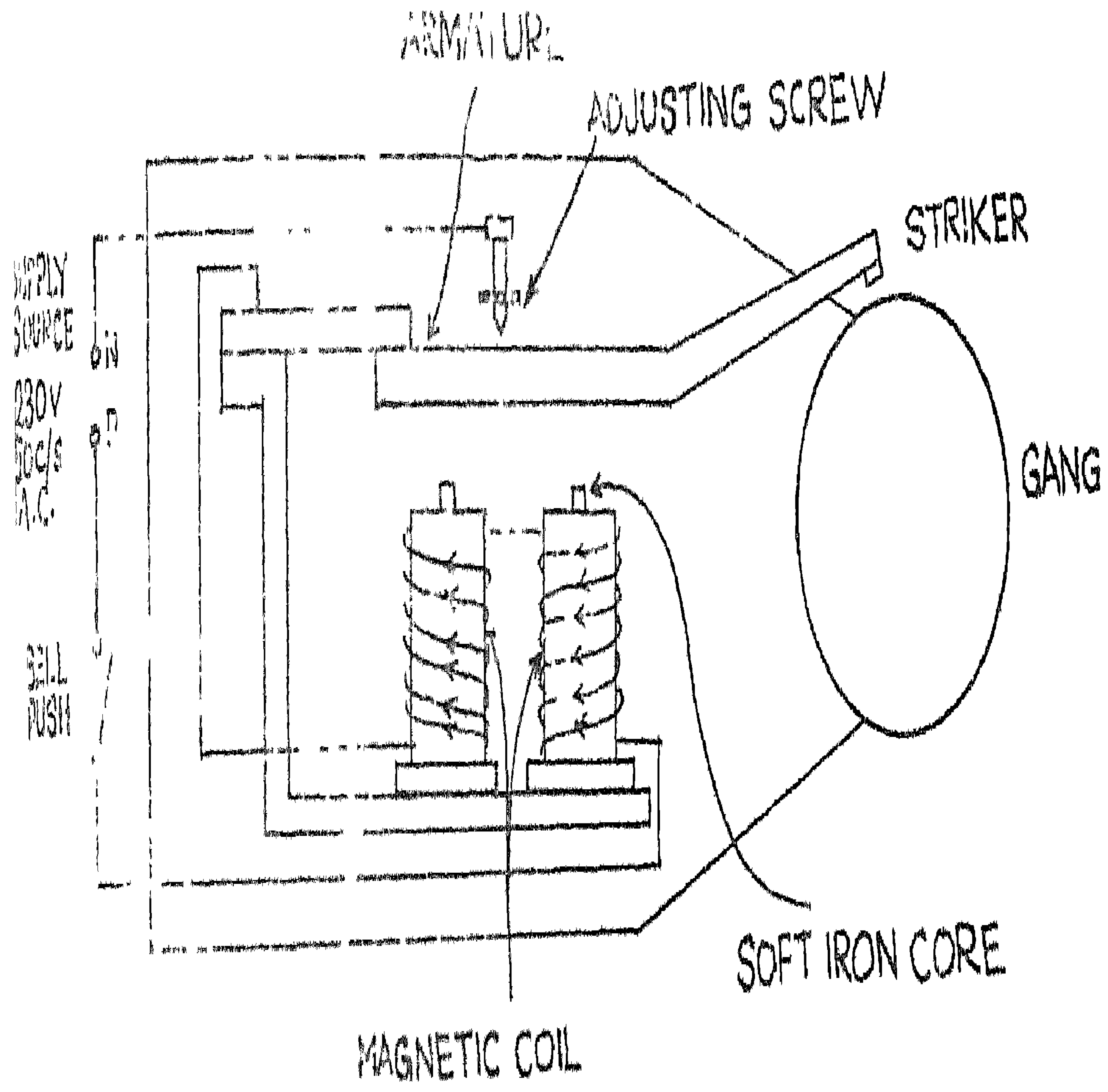
ii) List the various materials utilised for construction of an electric bell.

8. Precautions :

1. All the connections should be tight.
2. Check that the bell push is in working order.
3. Adjust the adjusting screw and be sure that it is touching the armature.
4. Test the continuity of magnetic coil using a test lamp.
5. Test that iron core is properly insulated.

9. Questions for evaluation :

1. What is the principle of an electric bell/relay ?
2. List out various parts of electric bell.
3. Name the materials out of which the following parts of electric bell are made-
   a) Gang
   b) Armature



CIRCUIT DIAGRAM

FIG. 9.1

c) Coils

d) Base Plate

e) Magnetic core.

f) Winding wire

4. Draw a neat sketch of electric bell.

5. What is the difference between an electric bell and buzzer.

6. What are the applications of an electric bell.

10. References:-

Electrical domestic appliances by Bhatia.

Experiment No. 10

1. Title of Experiment

To study the constructional details of a transformer.

2. Specific Objectives

i) To know different types of transformers.

ii) To dismantle a single phase transformer.

iii) To assemble transformer stampings.

iv) To know the method of winding primary and secondary coils.

3. Introductory Information and Related Theory:

A transformer is a static device. There are no rotating parts in it.

A transformer is normally used for changing a given voltage to another magnitude without changing the frequency. 'Mutual induction' is the principle of transformer.

N_1	Primary turns
N_2	Secondary turns
E_1	Primary Emf
E_2	Secondary Emf
I_1	Primary current
I_2	Secondary current

Emf, Current and turns ratio

$$\frac{N_1}{N_2} = \frac{E_1}{E_2} = \frac{I_1}{I_2}$$

Emf equation of transformer

$$E_1 = 4\ Kf\ \phi\ max\ f\ N_1$$

$$E_2 = 4\ Kf\ \phi\ max\ f\ N_2$$

Where Kf is form factor (For sinusoidal wave Kf=1.11)

Ø max is maximum flux

f is frequency.

There are three types of transformers.

1. Core type
2. Shell type
3. Berry type

The transformer core is assembled together as shown.

Low voltage windings are placed nearer to the core.

The coils are wound on a former using a coil winding machine.

4. Equipment and Materials:

   1. Transformer of suitable ratings 230V/12V/6V
   2. Screw Driver
   3. Test Lamp
   4. Cutting pliers

5. Voltmeter 0-300 V
6. Ammeter 0-15 A
7. Connector
8. Electrician Knife
9. Insulation tape
10. Standard Wire Gauge
11. Scale

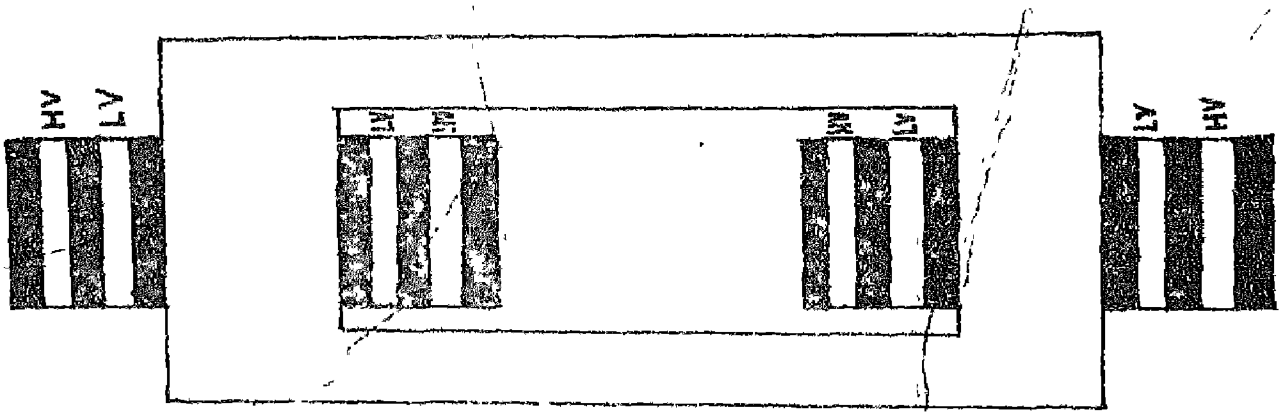
5. Circuit Diagram: See Figure [illegible] 1.

6. Procedure

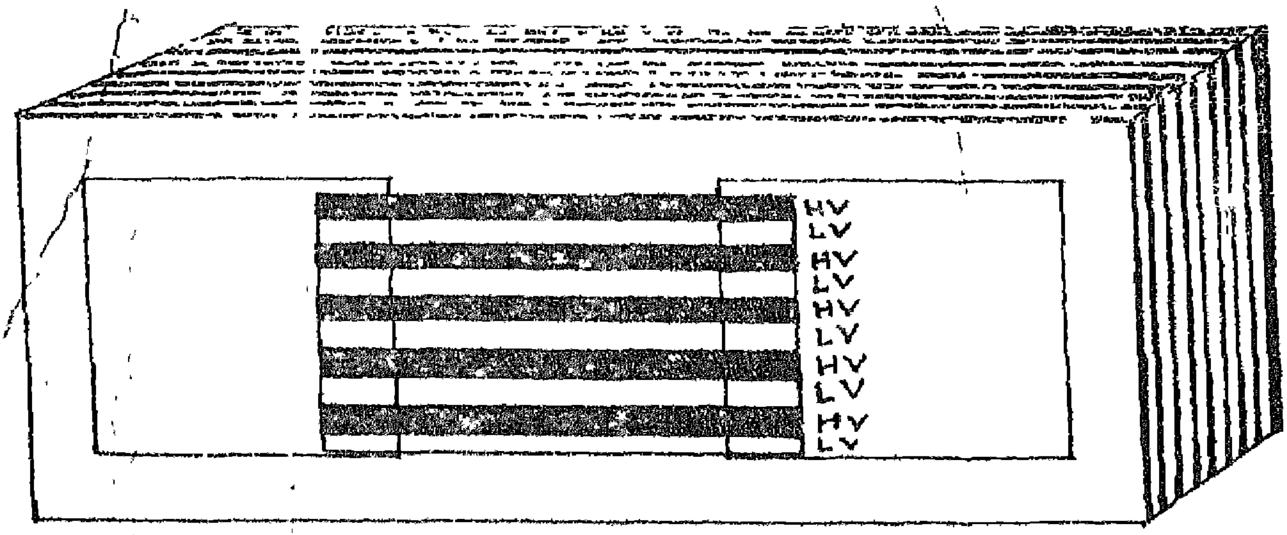
1. Connect the transformer as shown in the circuit di
2. Give supply from high voltage side and record the voltage on Low voltage side.
3. Dismantle the stampings step by step. Measure the dimensions of the stampings.
4. Identify the HV and LV windings using a test lamp.
5. Note the details of insulating materials used. List out the material and their specificatio
6. Check the gauges of the HV and LV windings using a S.W.G.
7. Count the number of turns on primary and secondary sides.

7. Record of Observations :

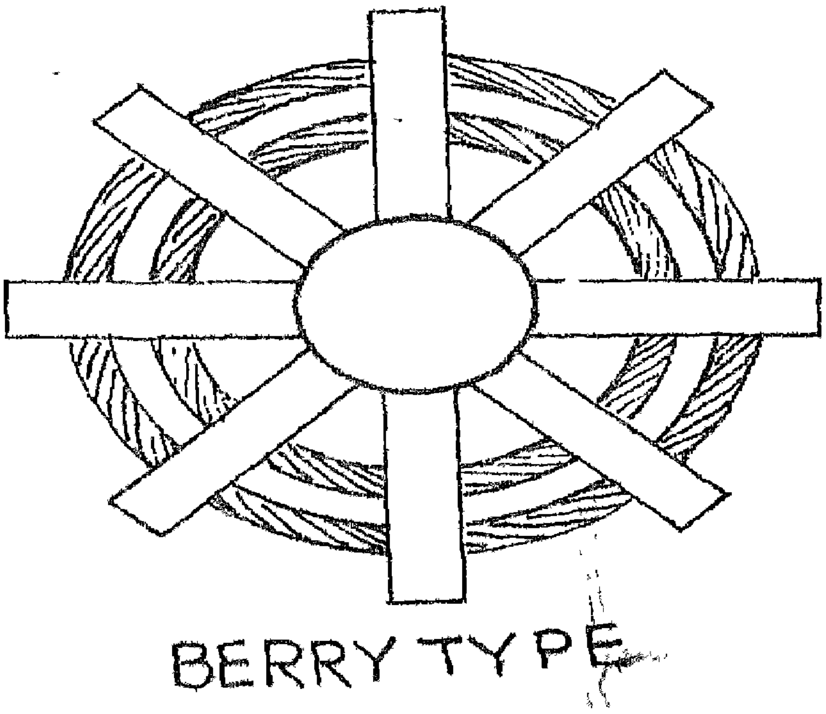
1. Voltage on HV side
2. Voltage on LV side
3. KVA



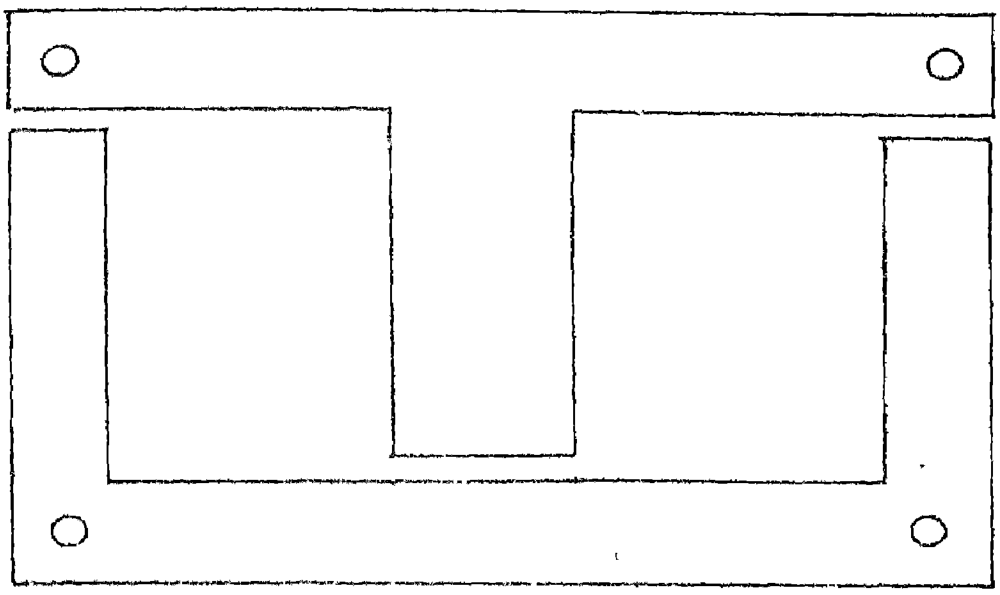
CORE TYPE
FIG. 10.1



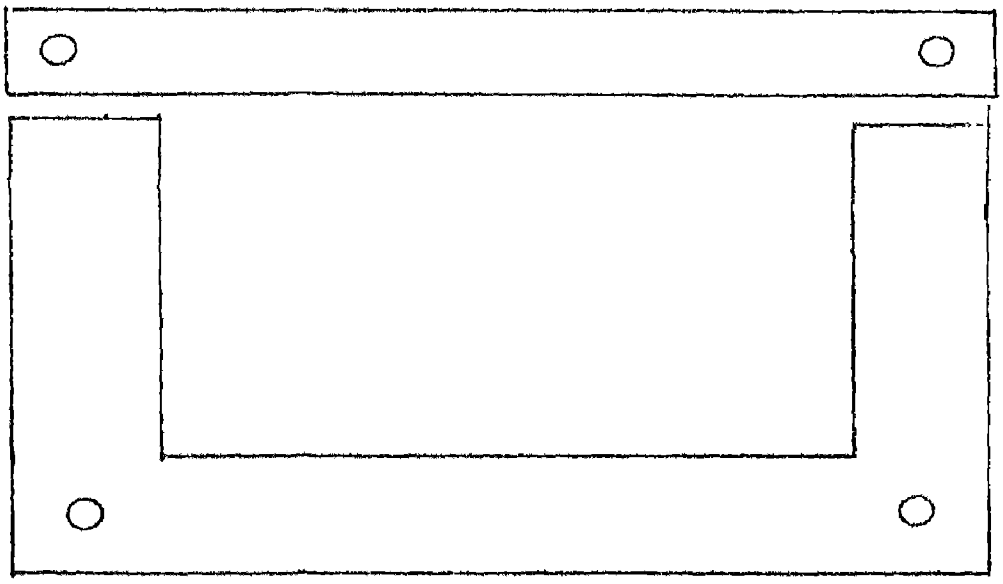
SHELL TYPE
FIG. 10.2



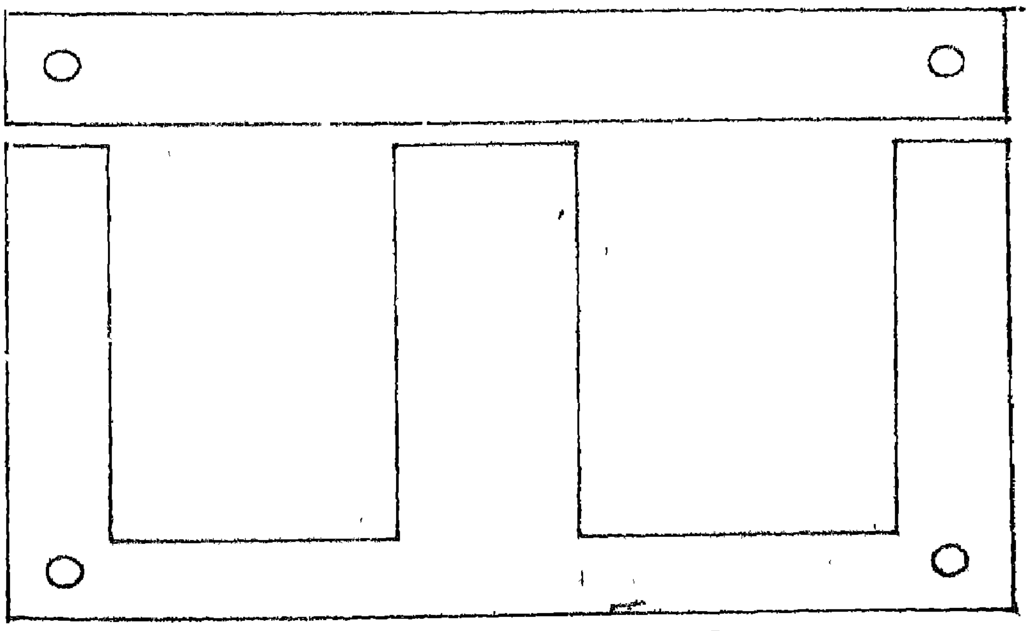
BERRY TYPE
FIG. 10.3



U &T STAMPINGS FIG 10-4



U & I STAMPINGS FIG 10-5



E & I STAMPINGS FIG 10-6

4. Dimensions of the stampings
5. Number of turns on HV side
6. Number of turns on LV side
7. Gauge number of winding on HV side
8. Gauge number of winding on LV side
9. Insulation details.

8. Precautions

1. Note all particulars of the transformer before dismantling
2. Use proper tools for proper job.
3. Do not damage the insulation material.
4. Do not be in haste while dismantling the transform
5. Do not damage the insulation of the stampings while handling.

9. Questions for Evaluation

1. What is the function of a transformer ?
2. What is emf equation of a transformer ?
3. What is the relationship between turns, voltage and current ?
4. How many types of transformers are there ?
5. Why LV winding is arranged nearer to the core ?
6. What are the insulating materials used in a transformer ?
7. Give a detailed account of dismantling of the transformer ?

10. References:

Electrical motor rewinding and repairs. by Anwani

Experiment No. 11

1. Title of Experiment

To wind a single phase transformer for a given design.

2. Specific Objectives

- i) To understand the construction of a transformer.
- ii) To know about the core, conductor and insulationg materials used in a transformer.
- iii) To dismantle the given transformer.
- iv) To test the given transformer.
- v) To repair the given transformer.
- vi) To rewind the given transformer.
- vii) To wind a new transformer.

3. Introductory Information and related theory

1. Transformer is a static device.
2. The losses in a transformer is less than in case of a rotating machines.
3. Transformer works on the principle of mutual induction
4. Transformer is of three types
    1. Core type
    2. Shell type
    3. Berry type

5. Transformer has the following parts
   1. Core stampings
   2. Primary and secondary windings
   3. Insulating material
   4. Miscellaneous items
6. The following is the preferred sequence of core formation.
   1. Round
   2. Square
   3. Rectangular
7. The core is made of special types of transformer steel.

DESIGN DATA

Primary voltage 230 v

Secondary voltage I 45 v

Secondary voltage II 1.8 v

VOLTAMPERES

45v x 3A = 135 VA

1.8v x 5.5A = 10 VA

Total Voltampere ....=145 VA

4 Turns per Volt

Primary winding 230 x 4 = 920 Turns N_1

Secondary winding I 45 x 4 = 180 Turns N_{2A}

Secondary winding II 1.8 x 4 = 7.2 Turns N_{2B}

Guage No. of wire

Primary winding - 23 SWG Super enamelled copper wire.

Secondary winding I - 17 SWG - Double silk covered.

Secondary winding II- 15 SWG - Double silk covered.

Courrents

Primary current

assuming 92% efficiency 0.65 Amperes

Window area 1.68 sq. inch (30% provided for insulation)

Width of the tongue of the core 15/16 inch.

Thickness of each stamping 0.014 inch

Number of stampings required 133

Bobbin size 1" x 2½"

Type of stampings U x T or E & I

4. Equipment & Materials

1. U & T or E & I shaped transformer stampings of suitable dimensions (Tongue width 15/16 inch thickness 0.014 inch) Approx. 150 Nos.
2. Super Enamelled copper wire SWG 23
3. Double silk covered or double cotton covered wire SWG 17 and 15.
4. Bobbin size 1" x 2 1/8 ".
5. Empire cloth.
6. Leatheroid
7. Pressphan.
8. Mica sheets
9. Dr. Beck insulating varnish.

10. Empire sleeves
11. Bolts and nuts of suitable size.
12. Coilwinding machine
13. Gasket shellac (Air drying)
14. Soldering iron
15. Soldering lead
16. Soldering flux.

5. Circuit Diagram : See diagrams attached

6. Procedure

1. Prepare the bobbin (1"x2$\frac{1}{3}$ ").
2. Insert a piece of wood to support the bobbin from inside.
3. Fix the bobbin on the coil winding machine.
4. Insulate the bobbin using proper insulation.
5. Wind high voltage winding nearer to the core. (since it is a small transformer). The primary winding should have 920 turn of 23 SWG super enamelled copper wire.
6. Use insulating paper after 3 or 4 layer's.
7. After finishing the primary winding take the leads out and insulate the primary winding properly.
8. Now take 17 SWG DSC wire and wind 130 turns and take out the leads through the bobbin.

9. Similarly take 15 SWG, DSC wire and wind 8 turns and take out the leads through the bobbin.

10. Take out the bobbin from the coil winding machine.

11. Take out the wooden support and test the coils using a series test lamp for short and open circuits.

12. Now take the U and T stampings and start inserting U stamping from left, T stamping from right side. Now insert U stamping from right and T stamping from left. Continue inserting the stampings from left and right alternatively.

13. While inserting 133 stampings, align the holes properly.

14. Now insert the bolts through the holes and the screws tight.

15. Test the transformer in the following order using test lamp.

    1. Series lamp test
    2. Ground test
    3. Short circuit test.

16. Make sure that there are no faults.
17. Now connect the primary winding to the supply (230v).
18. Measure the voltage on the secondary side
    (45 volt winding at 1.8 v windows).
19. Varnish the transformer and bake it.
20. Now the transformer can be loaded.

7. Tabular Record of Observ-ations

1. Dimensions of the stamping : ....
2. Primary turns : ....
3. Primary SWG No, : ....
4. Secondary (I) turns : ....
5. Secondary (I) SWG No. : ....
6. Secondary (II) turns : ....
7. Secondary (II) SWG No. : ....
8. Bobbin dimensions : ....
9. Primary voltage (designed) : ....
10. Primary voltage (Measured) : ....
11. Secondary (I) voltage (designed) ....
12. Secondary (I) voltage (measured) ....
13. Secondary (II) voltage(designed) ....
14. Secondary (II)voltage (measured)...............
15. Primary current on no load..................
16. Primary current on full load..................
17. Secondary(I) current on full load...............
18. Secondary(II) current on full load..............
19. Losses on no load (measured) ....
20. Losses recorded when secondary is short circuited. ....

8. Precattions

1. Handle the stampings carefully. Insulation should not be damaged.
2. Handle the wires carefully. Be careful about the enamel insulation on the copper wire.
3. Avoid kinks and knowts while handling the wire.
4. Wind carefully and arrange the layers neat.
5. Provide insulation paper for every 3 layers of winding.
6. Do not forget insulation between primary and secondary windings.
7. While taking out leads through bobbin do not damage it.
8. Insert the stampings with great care.
9. Do not forget to insert U and I stampings alternatively from right and left side.
10. Do not connect the transformer to the supply until all preliminary tests are completed.

9. Questions for evaluation

1. What is the function of a transformer ?
2. What is the principle of a transformer ?
3. What are the guages of wires used for different windings ?
4. What is the emf equation of a transformer ?
5. What is the relation between turns voltages and current ?

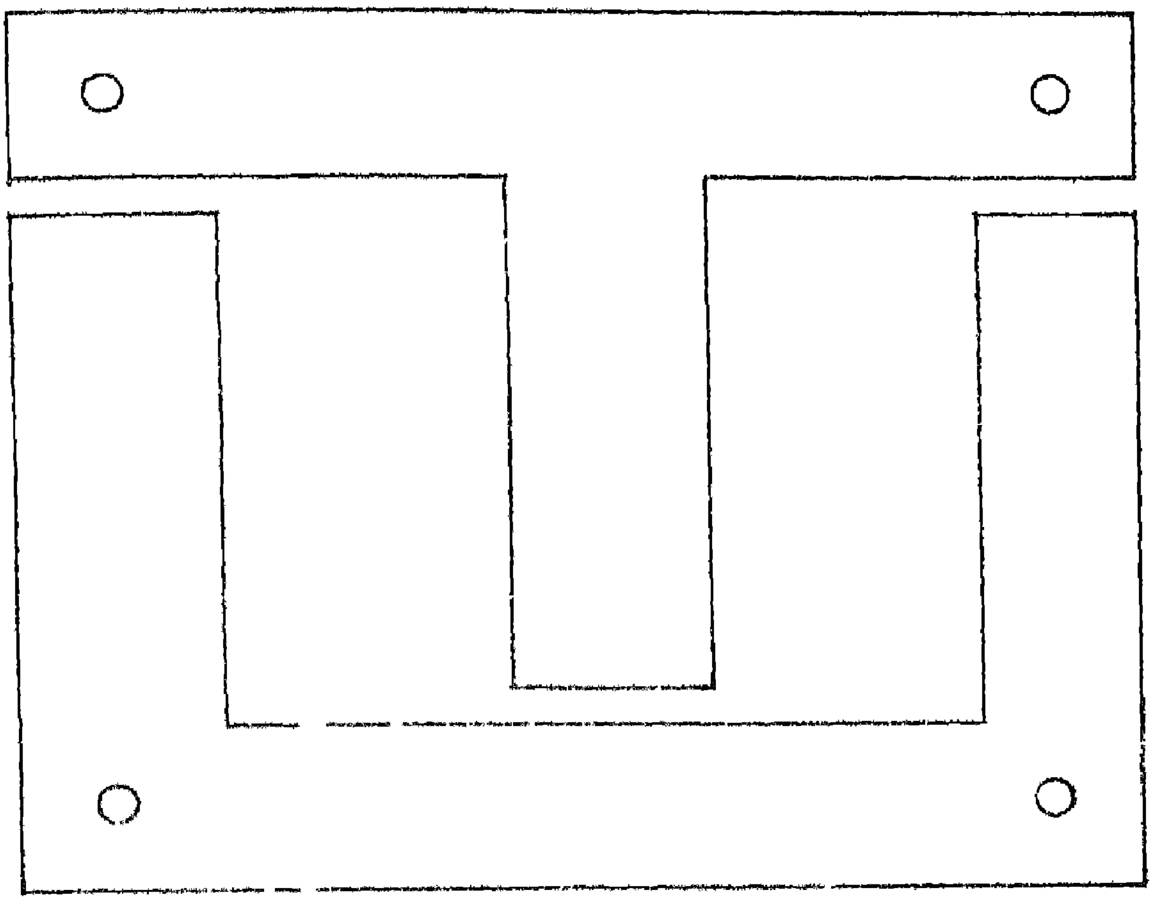


FIG 11.1. U &T

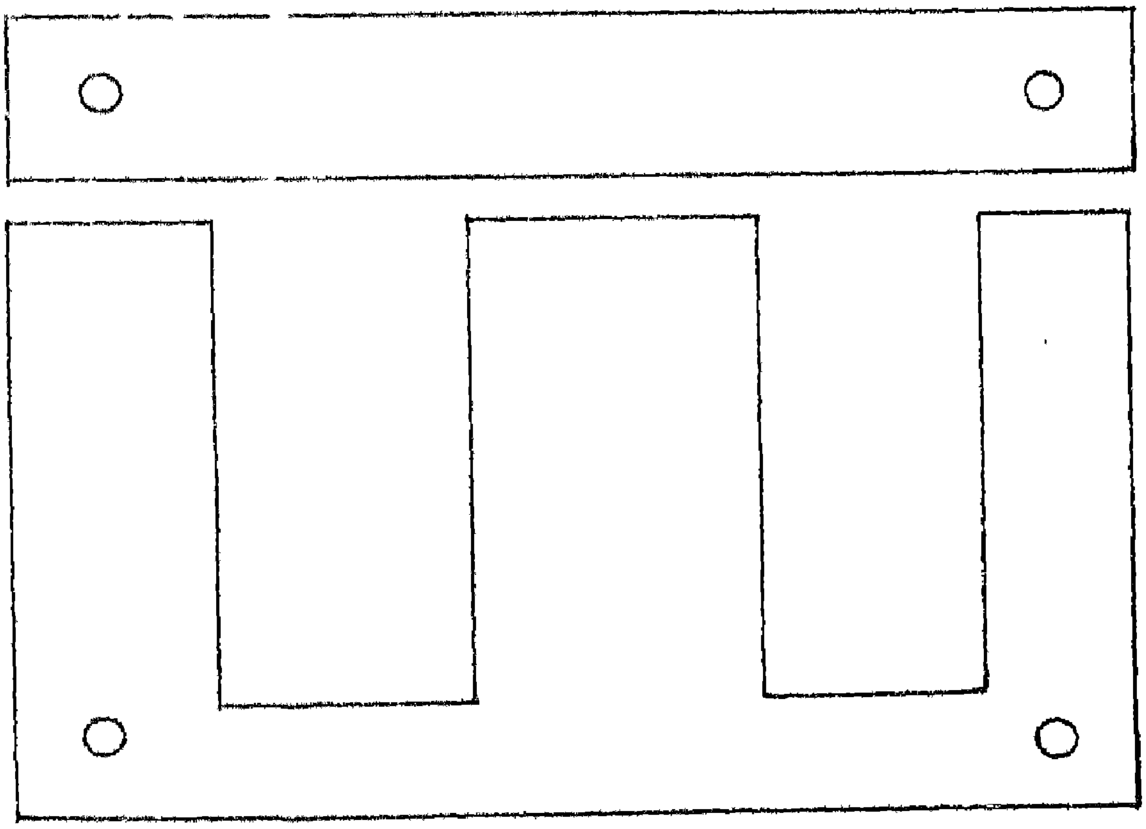


FIG 11.2. E & I

TRANSFORMER STAMPINGS ASSEMBLY

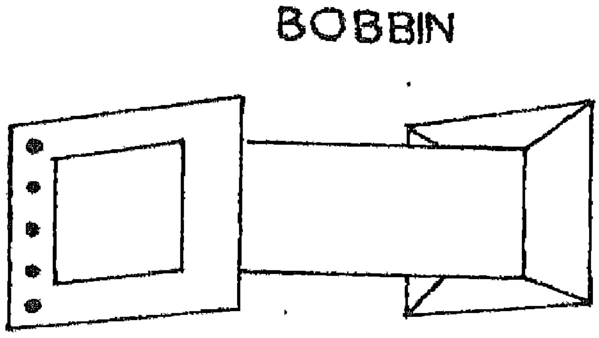


FIG 11.3

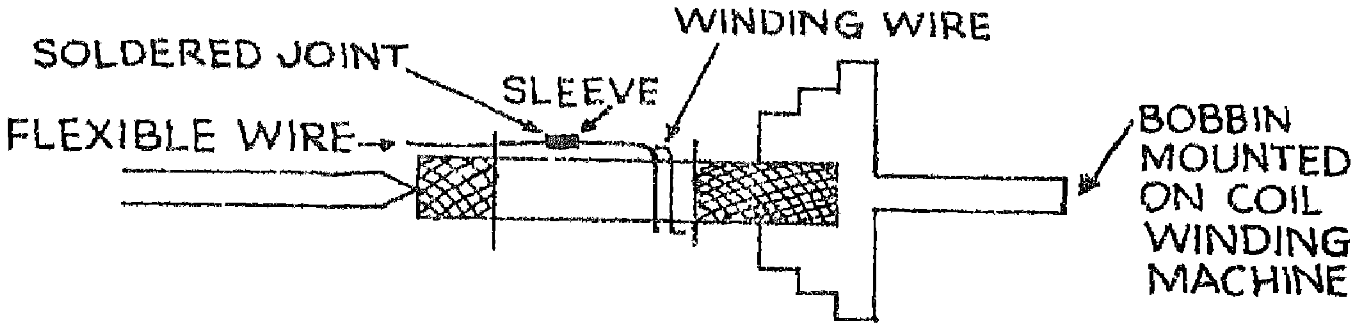


FIG 11.4

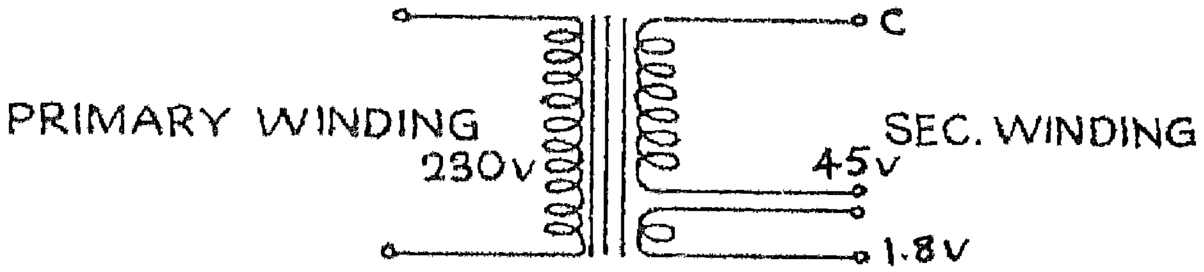


FIG 11.5

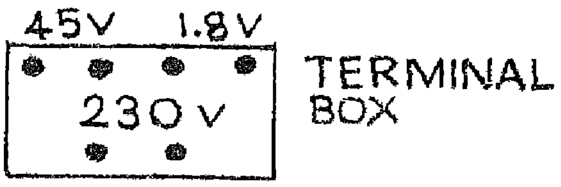
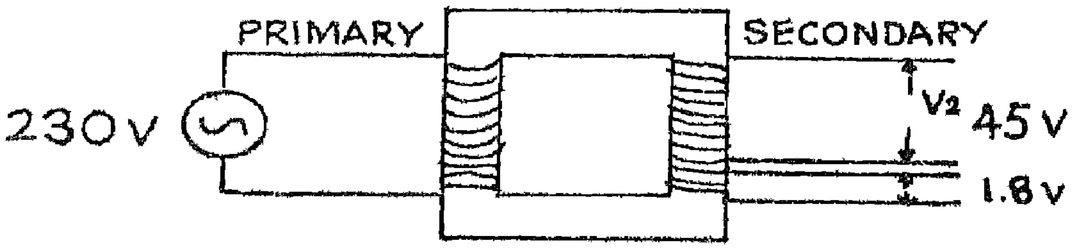


FIG 11.6



VOLTAGE TESTING

FIG 11.7

6. Explain the procedure of winding a transformer .
7. Explain the procedure of inserting the stampings.

10. References

A Textbook of Electrical Engineering by B.L. Theraja.

Experiment No. 12

1. Title of Experiment

To study rotating magnetic field using a three phase induction motor.

2. Specific Objectives

i) To get a clear concept of rotating magnetic field.

ii) To connect a three phase induction motor using a three phase auto-transformer.

iii) To use a three phase induction motor.

3. Introductory Information and Related Theory.

Three phase induction motor is a very widely used motor. Induction motor works on the principle of mutual induction.

An induction motor has a stator and rotor separated by an air of gap as shown in the figure NO.12.1

When a three phase voltage is applied to the three phase stator winding of induction motor a rotating magnetic field is set up.

Three coils are located with their axes spaced 120° apart. These coils carry three phase currents.

(fig 12.2.)

Rotating magnetic fields is an equivalent system of pole pairs rotating at synchronous speed.

(fig 12.3)

There are no salient poles but the poles are 'formed'. These poles are 'fictitious' and they rotate at synchronous speed.

4. Equipment and Materials

   1. A three phase induction motor.
      440V, 3ph, 50Hz, 1HP or 3HP or 5HP
   2. A three phase autotransformer.
      440V, 50Hz, 3ph, suitable for the motor.
   3. Ammeter 0-15A
   4. Voltmeter 0-600V
   5. Connecting wires

5. Circuit Diagram

   See fig 12.4 attached.

C. Procedure

   i) Connect the given three phase induction-motor using a three phase auto-transformer as shown.
   ii) Take out the rotor from the motor.
   iii) Place a drawing sheet on one side of the motor (in place of the end shield).

iv) Apply 5 or 10 percent voltage using the auto-transformer.

v) Sprinkle iron filings on the drawing sheet.

vi) Observe the formation of iron filings.

vii) Increase the voltage slowly and observe the iron filings.

7. Record of observations

i) Record the pattern of the filings.

ii) Note the change in speed as the voltage is increased.

8. Precautions

i) Make sure that the auto-transformer pointer is at zero position before switching on the supply.

ii) Do not apply more than 20 or 30 per cent of the rated voltage.

iii) Use proper wires.

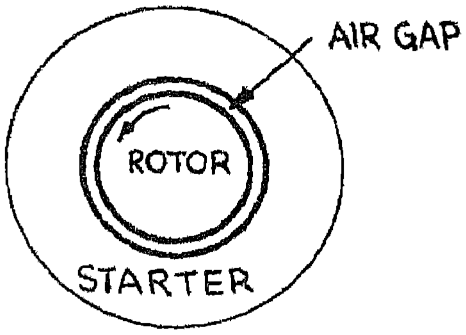
iv) Make all connections tight.

v) Get connections checked before giving supply.

9. Questions for evaluation:-

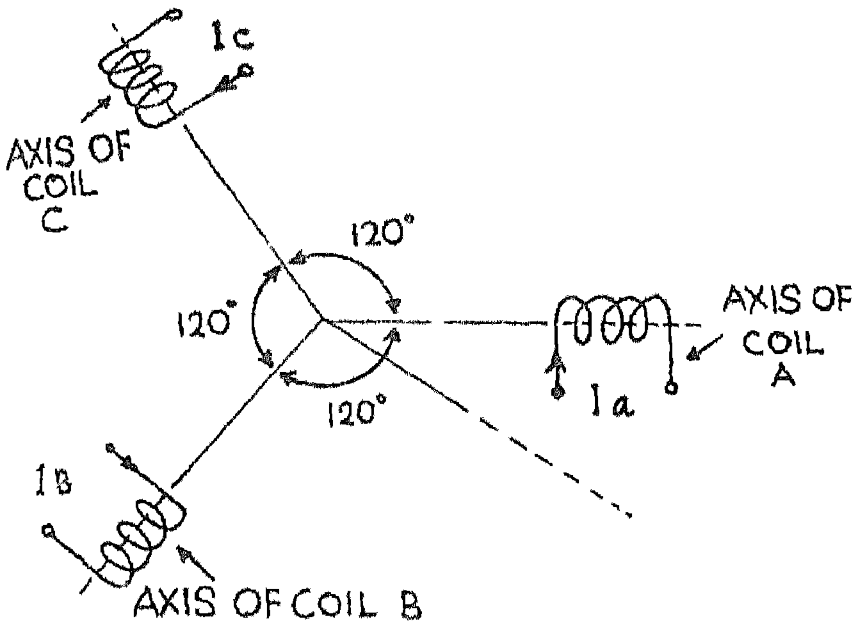
i) What is a rotating magnetic field ?

ii) Why there is no rotating magnetic field in case of DC machines ?



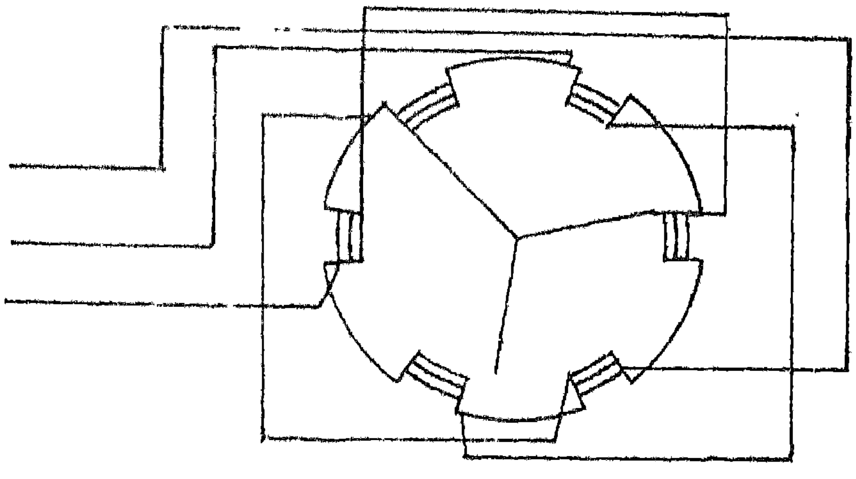
BASIC ROTATING MACHINE

FIG 12.1



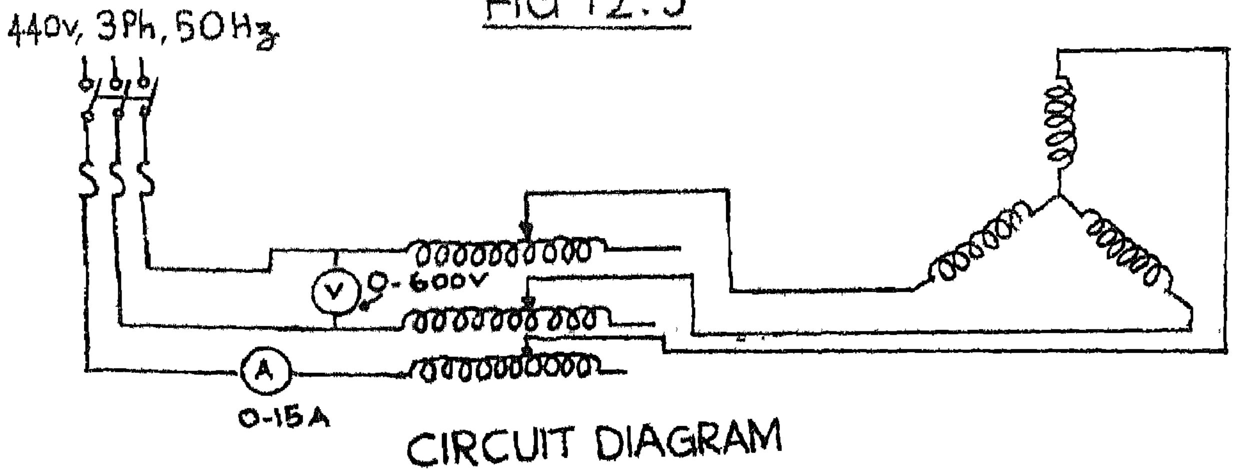
3Ph STARTER WINDING PRODUCING RMF

FIG 12..2



PRODUCTION OF RMF

FIG 12.3



CIRCUIT DIAGRAM

FIG 12.4

iii) What happens if rated voltage is applied to the stator without rotor in position ?

iv) Draw the pattern of iron filings.

v) What is the relationship between the speed of the RMF and applied voltage ?

10. Reference

A textbook of Electrical Engineering by B.L. Theraja.

Experiment No. 13

1. **Title of Experiment/Practical:**

To study the sinusoidal wave form through a C.R.O. and to determine amplitude and frequency.

2. **Specific Objectives:-**

i) To know the type and nature of wave form.

ii) To distinguish between A.C. and D.C. signal.

iii) To measure the repetitive rate (frequency) & to know the amplitude (maximum & Minimum)

iv) To know the periodicity of sinusoidal singal.

v) To understand the terms: R.M.S. value, average value, and form factor by actual measurement.

vi) To study the change of out put signal by connecting R,L & C separately.

3. **Introductory Information and Related Theory**

An A.C. voltage or current signal is generally sinusoidal in nature and is of periodic variety (i.e. the signal continues to be repetititive at different times). The signal is said to be purely sinusoidal if it contains only the fundamental frequency. A signal is said to contain higher frequency components, if it contains terms of 2x fundamental, 3,4 or 5 times fundamental frequency (fig 13.1 shows pure sinusoidal wave).

The signal is represented mathematically as $e(t) = e_m \sin wt$ where w is the angular fundamental frequency and e is said to be a periodic function of time. The maximum value occurs at $\pi/2$ (90°) and minimum occurs at $3\pi/2$ (270°)

The signal has zeros at $0, \pi, 2\pi, 3\pi$---------. (π rad = 180°) If the signal contains higher frequency terms, it is represented by

$$e = e_0 + e_{m_1} \sin wt + e_{m_2} \sin 2wt + e_{m_3} \sin 3wt + \ldots\ldots$$

Where e_0 is the d-c- term, e_{m_1} fundamental frequency term, e_{m_2} second harmonic term, and so on and so forth, such a signal is shown in fig. 13.2

The average value (full wave) is defined by $\frac{\int_0^T e_m \sin wt\,dt}{T}$ and is zero (Positive and negative part equal forfull wave). The average (Half wave) is given $\frac{2}{T}\int_0^{T/2} e_m \sin wt\,dt = 2\frac{E_m}{\pi}$. The r.m.s. value is defined by

$$\frac{1}{2\pi}\int_0^{2\pi} E_m^2 . \sin^2 wt . dt = E_m/\sqrt{2}$$

The frequency is defined by the repetitions made in 1sec (50 cycles/Sec or 50 Hz. The angular frequency is related by the angle in which the full wave complet the period $wT = 2\pi$ (T is the period) and $W = \frac{2\pi}{T} = 2\pi f$

The amplitude is the maximum or minimum value as the case be.

CRO (Cathode ray oscilloscope) is device for displaying the signals. On the instrument, you will find terminals for input, ground and putput. You will also find horizontal and vertical adjustment terminals. with these, you can reduce or expand the figure in horizontal as well as vertical directions.

4. Equipment and Materials.

i) C.R.O.

ii) A.C. Supply board fitted with Autotransformer (Voltmeter, ammeter and resistance, inductance and capacitance with terminal brought on the board)

5. Graph paper for recording output wave form.

Circuit Diagram: See diagram 13.3 attached.

6. Procedure:

Close Switch M.

Close switch 1 and move the auto transfermer to about 10% setting, open switch (2) and (3) and connect A to U. See the display, measure voltage wave form by taking out the display on graph paper, close switch 2 after switching off M and then connect B to U. close M. See the display. Now switch off M and close switch 3 and connect C to U. Measure maximum anmplitude and frequency in all the three cases.

Now switch off M and increase auto setting to 20% Close M repeat all the parts above in the same manner. Again close M and set the auto tap to 40% and then close M. Again repeat all the parts. Please note that steps of closing the main and other switches remain the same.

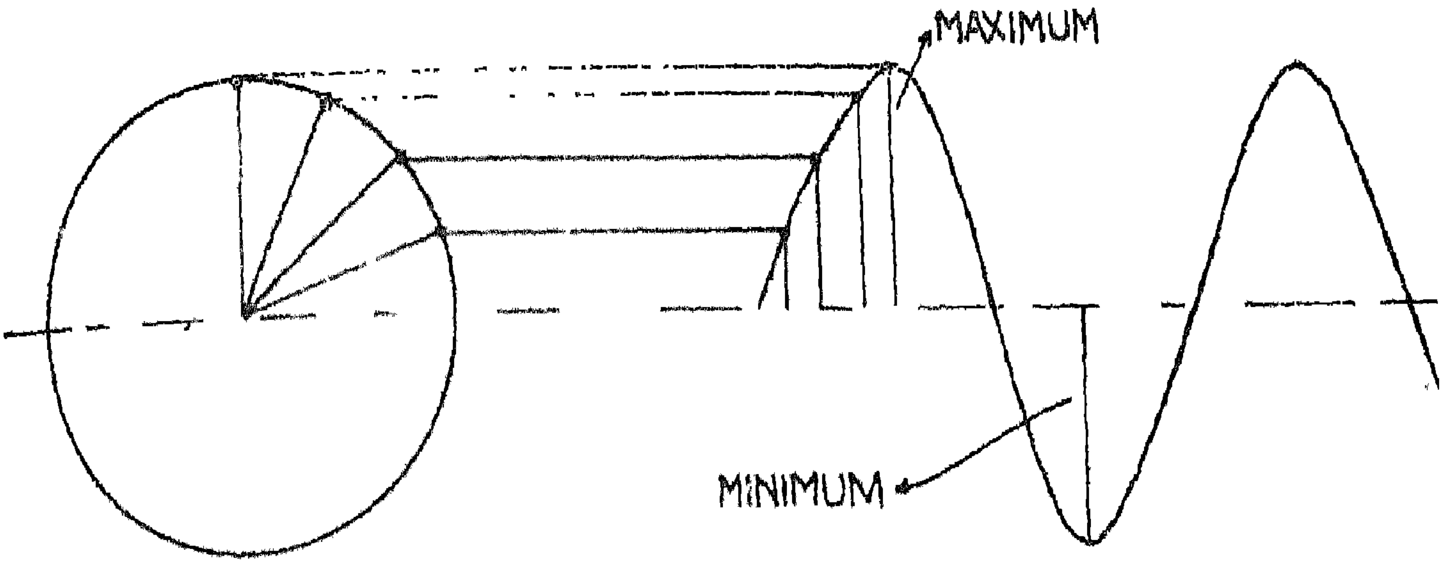
Tabular record of observations :

8. Precautions:

1. Please check if supply is available.
2. Keep switch M off before each connection is made.
3. Be careful in making connections.
4. Please ensure that all components in series and parallel are connected as they should have been.
5. Measure the display of C.R.O. very carefully.
6. Take readings only when the instruments and C.R.O. has settled down.

9. Questions for evaluations:-

1. What is the difference between a.c. and d.c. wave form?
2. What is the basic difference between periodic and aperiodic signal?
3. What is frequency ? How will you measure it ?



PURE SINUSOIDAL

FIG 13.1

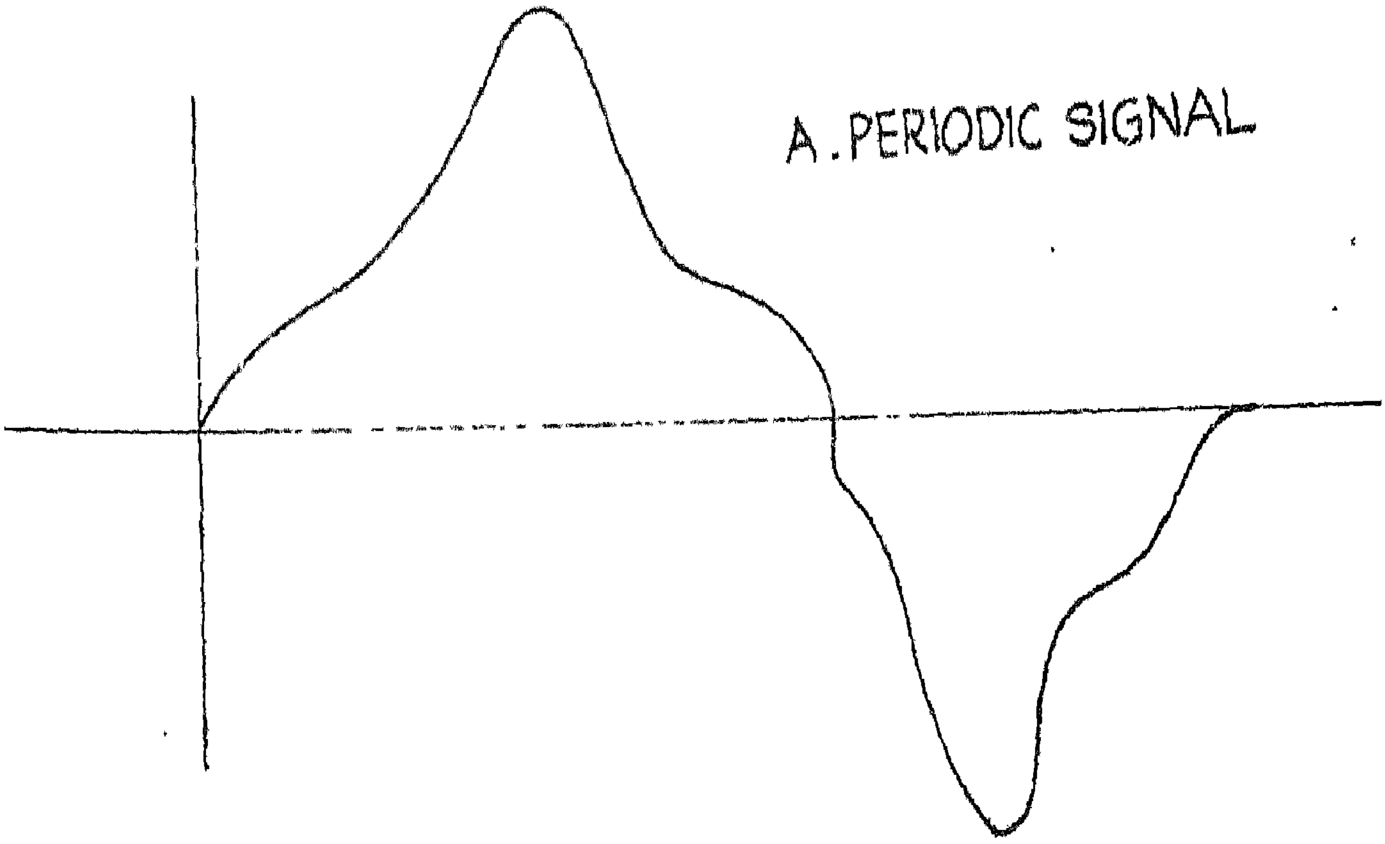
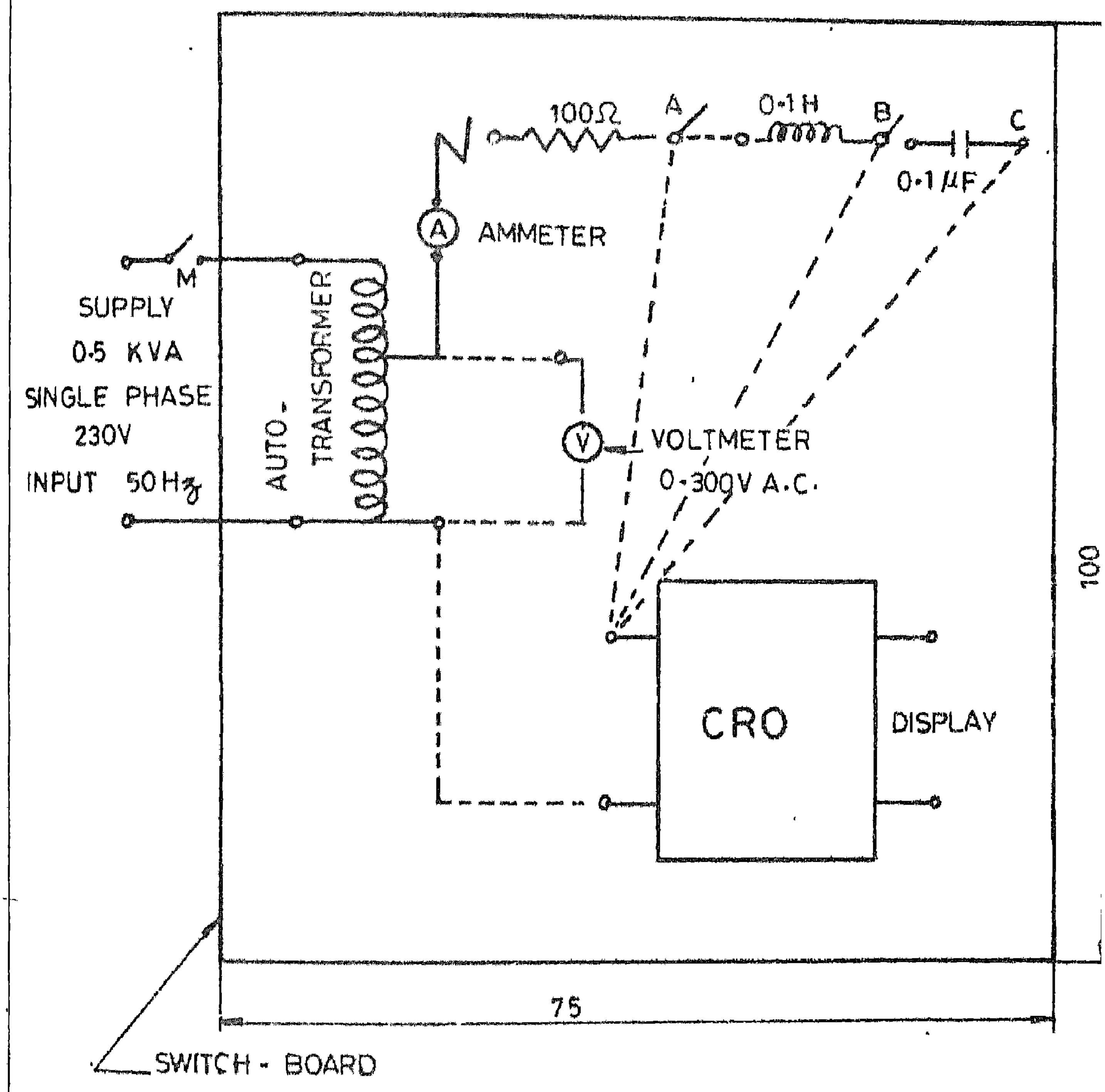


FIG 13.2



CIRCUIT DIAGRAM

FIG. - 13·3

4. Explain the physical significance of r.m.s. value of an a-c wave form.
5. Do you note a difference between the cases (a), (b), & (c). State why you do/donot get the difference.
6. What is a third harmonic, can you find out 3 harmonic content in your signal ?
7. Why do you apply different voltages through various tap settings of an auto transformer.
8. Why the average value of full wave is Zero and it is not for the half wave.
9. What is form factor. Is this different for periodic and aperiodic signals.
10. Comment on your observations.

10. References:-

A. C. circuits-Kirchner and Corcoran.

Product : $= V_m I_m \sin wt \sin (wt - \phi)$

$= \frac{V_m I_m}{2} \{\cos \phi - \cos (2 wt - \phi)\}$

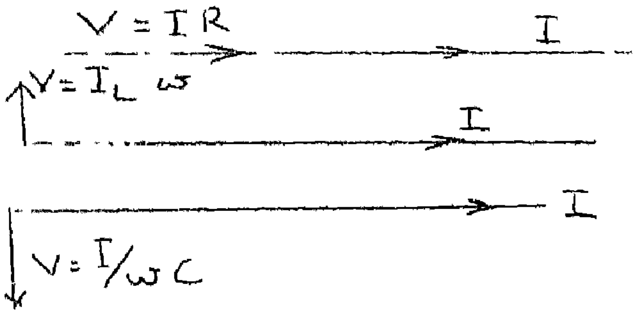
Again the average $= \frac{V_m I_m}{2} \cos \phi = \frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} \cos \phi = VI \cos \phi$ Power. In case of pure inductance ($\phi = 90$) and power $= 0$ ($\cos \phi$ is the p.f. of the circuit).

In case of capacitance the current leads the applied voltage by angle ϕ. i.e. if $V = V_m \sin wt$ $i = i_m \sin (wt + \phi)$ and VI product $= \frac{V_m I_m}{2} \{\cos \phi - \cos (2 wt + \phi)\}$ again the average power $= \frac{V_m i_m}{2} \cos \phi = VI \cos \phi$. However in case of pure capacitance $\phi = 90$ and Power is zero. Therefore, Power is consumed in R-L, R-C, R-L-C series circuits due to resistance only. In parallel R-L, R-C, R-L-C circ power will be consumed only in resistive parts. The vector diagram for all the cases are drawn below:

i) Pure resistance

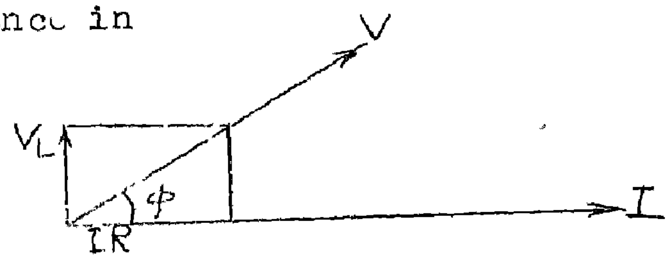
ii) Pure Inductance

iii) Pure Capacitance



iv) Resistance and Inductance in series

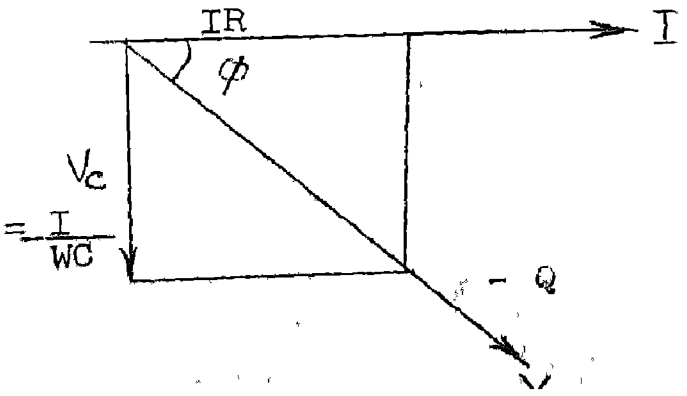
$$\cos \phi = \frac{R}{(R^2 + L^2 \omega^2)^{1/2}}$$



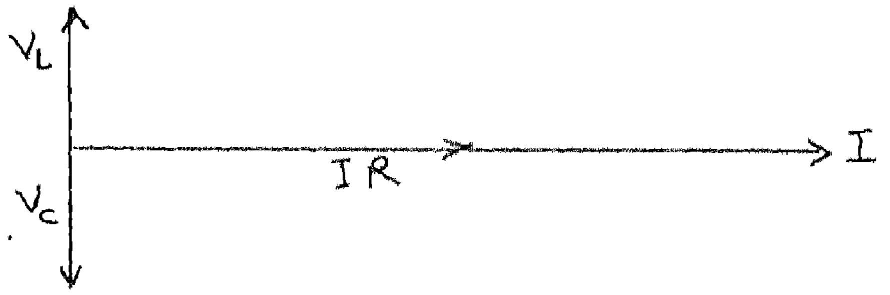
v) Resistance and capacitance in series.

$$\cos \phi = \frac{R}{\left(R^2 + \frac{1}{\omega^2 C^2}\right)^{1/2}}$$

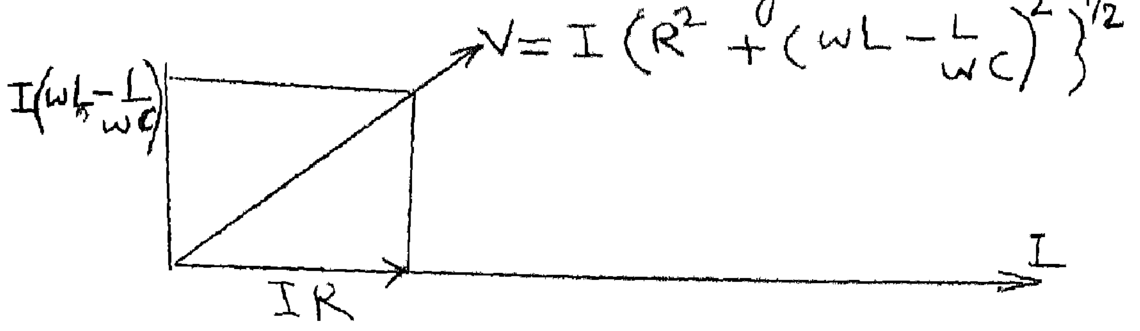
$$\cos \phi = \frac{\omega C R}{(1 + R^2 \omega^2 C^2)^{1/2}}$$



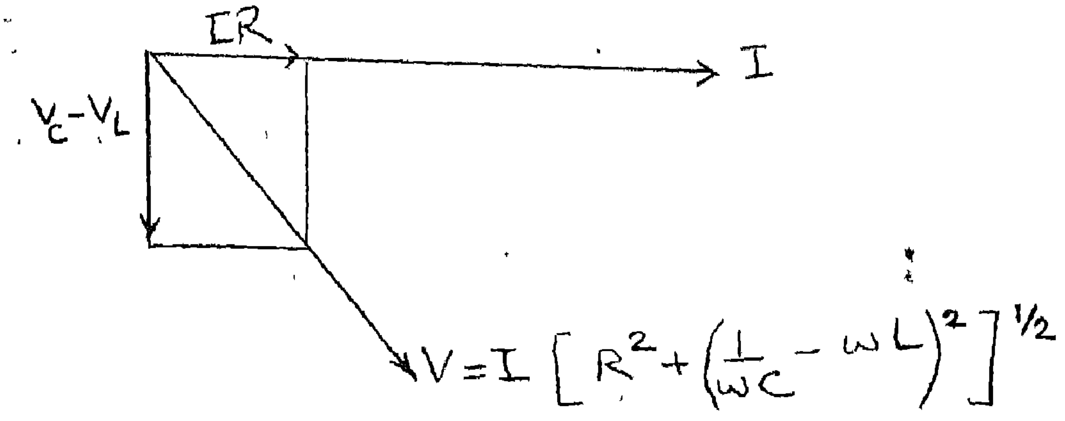
6. Resistance, inductance and capacitance in series.



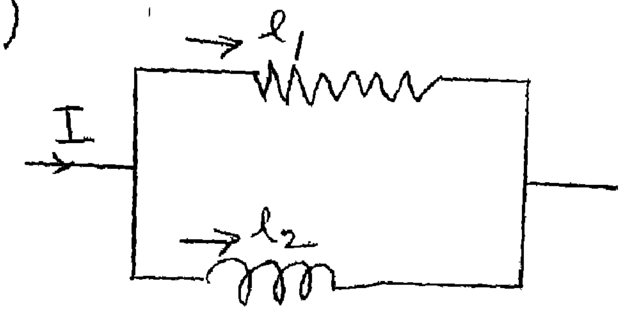
Assuming $V_L > V_C$, the diagram reduces to the following


$V = I\left(R^2 + (\omega L - \frac{L}{\omega C})^2\right)^{1/2}$
$I(\omega L - \frac{L}{\omega C})$
IR
I

If $V_C > V_L$, the diagram reduces to the following.


IR
I
$V_C - V_L$
$V = I\left[R^2 + (\frac{1}{\omega C} - \omega L)^2\right]^{1/2}$

(7)

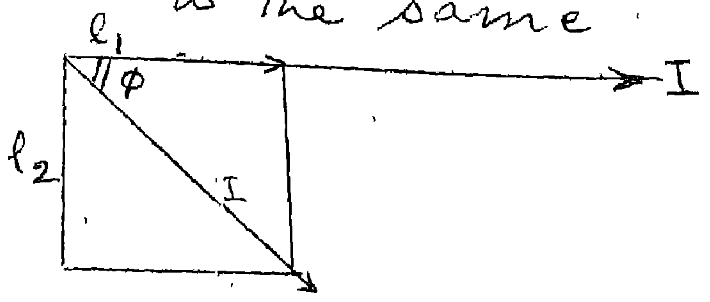


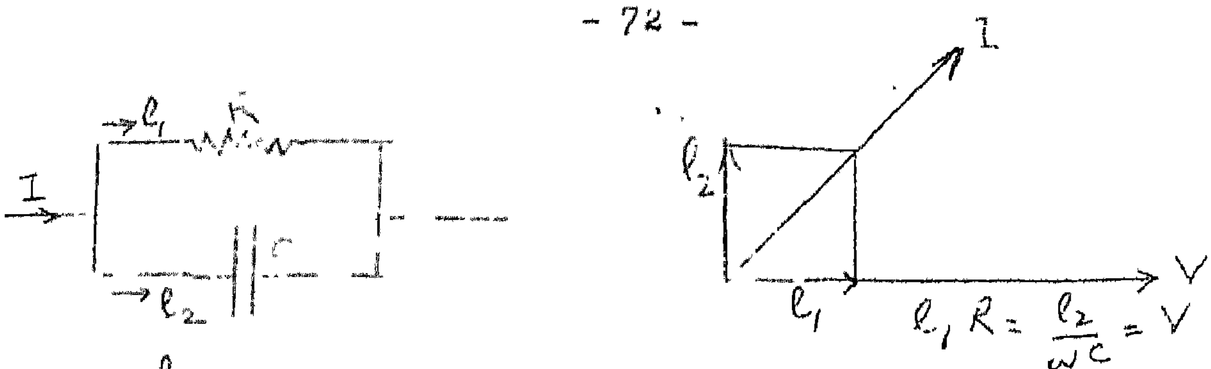
V is taken as the reference since the applied voltage is the same!

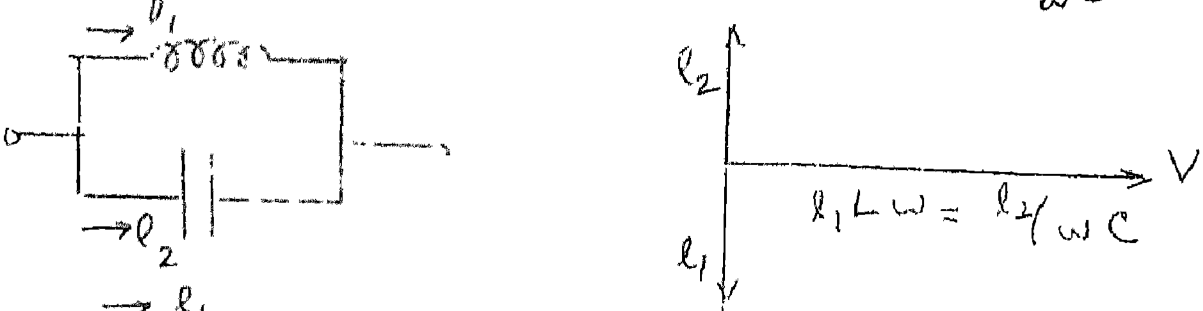
$$\ell_1 = \frac{V}{R}$$

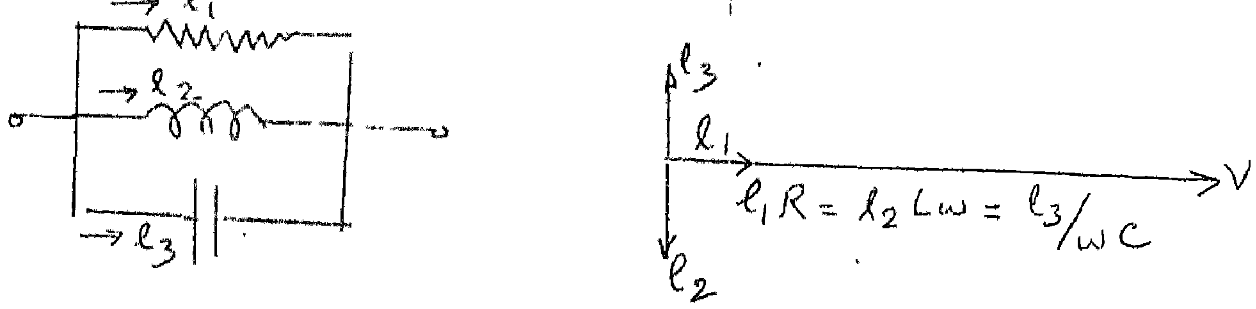
$$\ell_2 = \frac{V}{\omega L}$$

$$I = (\ell_1^2 + \ell_2^2)^{1/2}$$









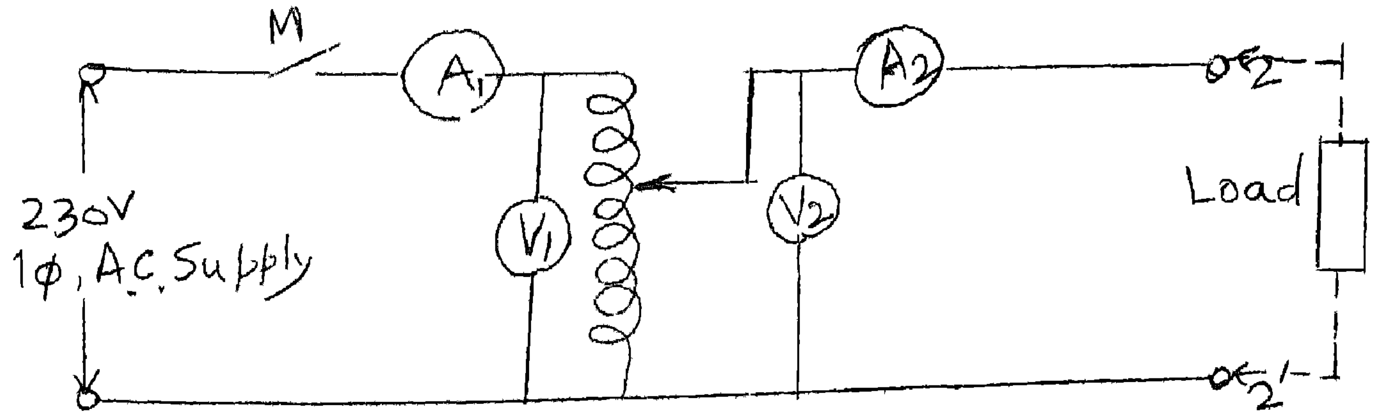
4) Equipment and Materials:

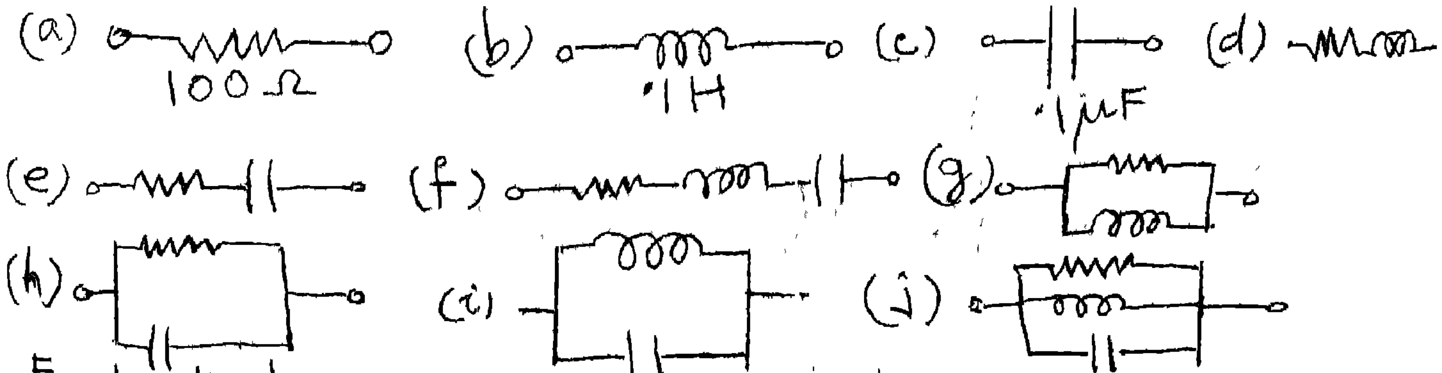
(1) Resistance, inductance and capacitance of 100 .1H and 0.1 uF

(2) Autotransformer 0-230 V, 5 Amps, 1 KVA

(3) Voltmeter (0-300 V A.C), Ammeter (0-10 Amp A-C) and Wattmeter (0-5 KW)

(5) Circuit Diagram :-





Each to be connected across 2-2' one by one

6. **Procedure:-**

Connect the circut as shown in the diagram. Do not close switch M till complete check up of the circuit has been made by you. Vary the Variac and set it up at 50%. Connect the resistance as shown in (a). close M and take the readings of the line current (A1) line voltage V_1, circuit voltage V_2 and circuit current A_2. Now switch off M and connect the inductor as shown in (b). Take the readings as before. Similarly connect the capacitor after removing the inductor and take readings. Repeat this exercise for (d) (R-L in series), (e) (R-C) in series (f) (R-L-C) in series. Now connect R & L in parallel across 2-2. Repeat the readings as before. Do this exercise for steps in h, i and (JI).

7) Tabular record of observations:

S.No.	Line Voltage V1	Line Current A1	Circuit Voltage V2	Circuit Current A 2	Check of yough the following
1					$V_2/I_2 = R$
2					$V_2/I_2 = Lw$
3					$V_2/I_2 = 1/wC$
4					$V_2/I_2 = (R^2+L^2w^2)^{1/2}$
5					$V_2/I_2 = (R^2+1/w^2c^2)^{1/2}$
6					$V_2/I_2 = \left(R^2+\left(Lw-\frac{1}{wc}\right)^2\right)^{1/2}$
7					$I_2 = V(1/R^2+1/L^2w^2)^{1/2}$
8					$I_2 = V(1/w^2L^2+w^2c^2)^{1/2}$
9					$I_2 = V(1/R^2+w2c^2)^{1/2}$
10					$I_2 = V(1/R^2+1/L^2w^2+w^2c^2)^{1/2}$

Then Draw Vector diagrams as shown in theory.

8. Precautions:

1) Do not close switch M till you have checked up the complete circuit.

2) Do not exceed the tap setting of auto transformer by more than 50%

3) All voltmeters should be connected in parallel and all ammeters in series.

4) All circuits in (a) to (j) should be connected across 2-2.

5) The instruments should be of proper rating.

9) Questions for Evaluation:-

1) What is power factor

2) What is the value of p.f for a pure resistor, inductor and capacitor.

3) Explain why there is no power consumption in a series L-C or parallel L-C circuits.

4) Why do you take current as the reference in series circuts and voltage in parallel circuits.

5) What do you mean leading or lagging phase angles of current with respect to voltage.

6) Under what condition voltage across the inductor or capacitor in a series R-L-C may exceed the supply voltage.

7. How can you improve or reduce the power factor in a series or parallel A.C. Circuits.

8. Draw wave forms for leading and lagging currents.

9. Draw vector diagram for circuit consisting of LC in parallel and in series with a resistance. What reference you will take and why ?

10. Explain why an auto transformer is employed in the circuit diagram

References:- A.C Circuits by Kirchner and Corcoran.

Experiment No. 15

1. **Title of Experiment/Practical:-**

   Impedance calculations and measurements on series, parallel and series parallel circuits.

2. **Specific Objectives:**

   1. To observe impedance of series circuits (R-L, R-C, R-L-C)
   2. To observe impedance of parallel circuits (R-L, R-C, L-C, R-L-C)
   3. To observe impedance of series parallel circuits (R-L in series with R-C in parallel, R-C in series and R-L in parallel)
   4. To measure power and power factors of different circuits.
   5. ∠ cirduit To vary resistance of series R-L E ∠ and to note the variation in impedance.
   6. To vary resistance of parallel R-C circuit and to note the variation of impedance and power factor.
   7. To vary resistance of parallel R-L circuit which is in series with a capacitor and to note the change of impendence and power factor.

3. **Introductory Information and Related Theory**

   When an a.c. voltage is applied to a R-L series circuit, the law between voltage and current is given by $v=IZ$ where $Z = (R^2+ w^2 L^2)^{1/2}$ and the cosine of the angle between voltage and current given by $\cos \phi = \frac{R}{Z}$ if resistance is very small as compared to wL (reactance) Cos Ø is very small and the circuit is referred as inductive. In case of a series R-C circuit, $Z = \left(R^2 + \frac{1}{w^2c^2}\right)^{1/2}$ and again if $1/wc \gg R$, then the power factor will be very small and the circuit will be referred as capacitive. However if $wL \ll R$, the circuit will be ∠ as a resistive circuit.

∠ known

For parallel case (R-L), $/Z/ = \frac{wLR}{(R^2+w^2L^2)^{1/2}}$ if R is very small the magnitude of impedance /Z/ incase $R \gg wL$, $/Z/ = wL$. In case of parallel RC circuit, the magnitude of impedance is given by- $/Z/ = \frac{R}{(1+w^2R^2c^2)^{1/2}}$ – Note that if $wRC = 1$, $/Z/ = \frac{R}{\sqrt{2}}$ Similarly for various values of R, wRC will attain different values and the impedance will vary. The power factors for parallel R-L and R-C are given by $\cos Ø = \frac{R}{(R^2+w^2L^2)^{1/2}}$ (R, L) and $\cos Ø = wCR/(1+w^2C^2R^2)^{1/2}$

For R-L in series and R-C in parallel the total impendance is vectorial sum of impedance (R-L) and impedance R-C, It can be obtained by

$$Z = \vec{Z}_{R-L} + \vec{Z}_{R-C}$$

$$Z = R_1 + j\omega L + \frac{R_2(-j/\omega C)}{R_2 - j/\omega C}$$

$$= R_1 + \frac{R_2}{(1+\omega^2C^2R_2^2)} + j\left(\omega L - \frac{R_2^2\,\omega C}{1+R_2^2\omega^2C^2}\right)$$

and

$$\cos\phi = \frac{R_1 + R_2/1+\omega^2c^2R_2^2}{\left\{\left(R_1 + \frac{R_2}{1+\omega^2C^2R_2^2}\right)^2 + \left(\omega L - \frac{R_2^2\,\omega C}{1+R_2^2\omega^2C^2}\right)^2\right.}$$

In an identical fashion, the total impedance of parallel R-L in seres with a capacitor can be worked out as

$$\vec{Z} = \vec{Z}_{R-L} + \vec{Z}_C = \frac{R_1(jwL)}{R_1 + jwL} - j/wC$$

$$= \frac{w^2L^2R_1}{R_1^2 + w^2L^2} + j\left(\frac{wLR_1}{R_1^2+w^2L^2} - \frac{1}{wC}\right)$$

and

$$\cos\phi = \frac{\dfrac{w^2L^2R_1}{R_1^2+w^2L^2}}{\sqrt{\left(\dfrac{w^2L^2R_1}{R_1^2+w^2L^2}\right)^2 + \left(\dfrac{wLR_1}{R_1^2+w^2L^2} - \dfrac{1}{wC}\right)^2}}$$

4. Equipment and Materials

1. Two variable resistors of 100 ohms-2 amp rating
2. Two inductors of 1 H and 1MF each of 1 amp rating
3. Auto transformer of 1.0 KVA, 230 Volts input
4. Voltmeters (0-300V A-C) (1 No) and (0-150 V A C.) (2 Nos)
5. Ammeters (0-5 Amp) (1 No) &(0-3 Amp - 1 No)
6. Wattmeter (0-300 V Pressure coil) (0-5 amps - Current Coil) - one no.

5. Circuit diagram - See the diagrams attached.

6. Procedure:-

1. Make the connection diagrams as shown and do not close switch M unless you have ensured that all connection are in order,
2. Vary the Variac and set it at 50% tap setting.
3. Connect the impedance (a)" across 2-2' with resistance set at 100 ohms.
4. Close the switch M & take readings of V_1, A_1, V_2, A_2, wattmeter, and V_3.
5. Switch off M and connect b. Take the readings of V_1, A_1, V_2, A_2 wattmeter and V_3 after closing M.
6. Every time switch off M and connect circuits C to (i) and take readings of V_1, A_1, V_2, A_2, wattmeter and V_3 after closing switch M.
7. Now switch off M and connect the circuit across 2-2' as shown in j. Set the resistance to 0 and then switch on M. Very the resistance and take readings for V_1, A_1, V_2, A_2, wattmeter and V_3 every time with variation in steps up to full value of resistance.

8. Again switch off M and connect the impedance in K. .. Set the resistance to zero value and close switch M. Vary the resistance and take readings for V_1, A_1, V_2, A_2, wattmeter and V_3 every time with variation in steps up to full value of resistance.

9. Repeat the same exercise in the identical manner for 1.

Tabular record of observations:

S. No.	Case	Line voltage volts	Line Current Amps	Input voltage Volts	Input Current Amps	Wattmeter reading watts	Circuit voltage volts	Impedance ohm	Power factor
1	a								
2	b								
3	c								
4	d								
5	e								
6	f								
7	g								
8	h								
9	i								
10									
(1)									
(2)									
(3)	j								
(4)									
(5)									
11									
(1)									
(2)									
(3)	k								
(4)									
(5)									
12									
(1)									
(2)	l								
(3)									
(4)									
(5)									

8. **Precautions:-**

(i) The connections must be tight

(ii) The components across the parallel and series must be checked before the switch M is closed

(iii) It should be ensured that the autotransformer's setting has been made at 50%

(iv) The pressure coil terminals should be connected between 0-300V or 0-150 volts and the multiplying factor should be noted.

(v) The instruments should be of proper rating.

9. **Questions for evaluations:-**

(i) What is inductive reactance ?

(ii) How can you vary the impedance of series R-L or parallel R-L circuits ?

(iii) How can you make the power factor low or high ?

(iv) Why it is desirable to get high power factors rath[illegible] then low power factor.

(v) In circuits (i) & (1), is it possible to achieve unity power factor, if so how.

(vi) In which circuits you get th condition of resonance. Explain the conditions under which it occurs.

(vii) What important informations you get from this experiment.

10. **References:-** Alternating current circuits by Kircan and Corcoran.

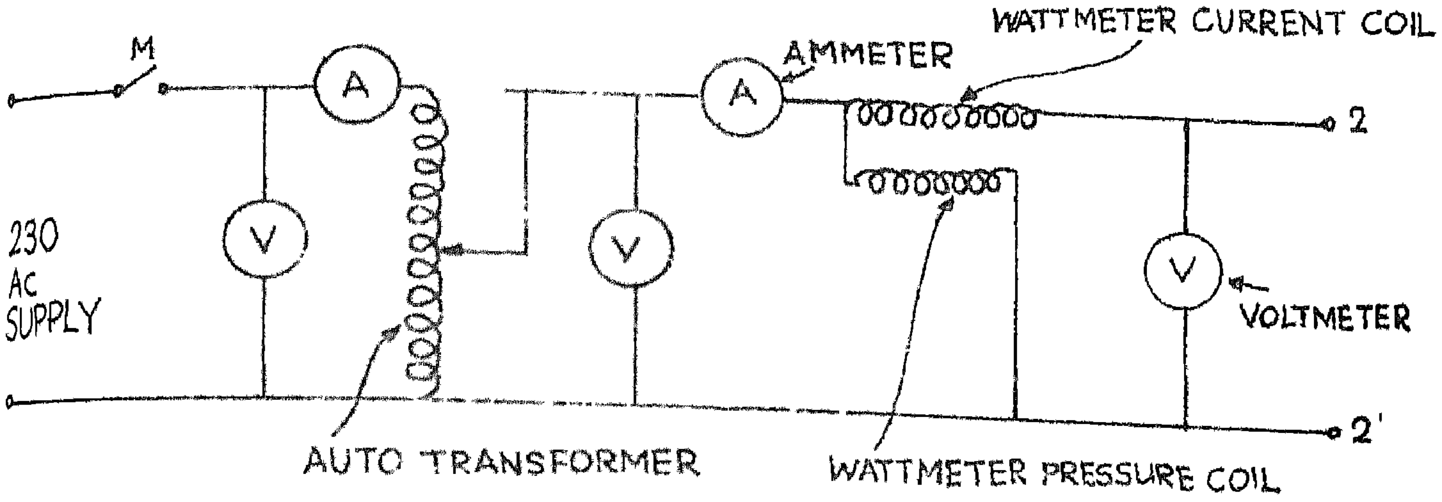
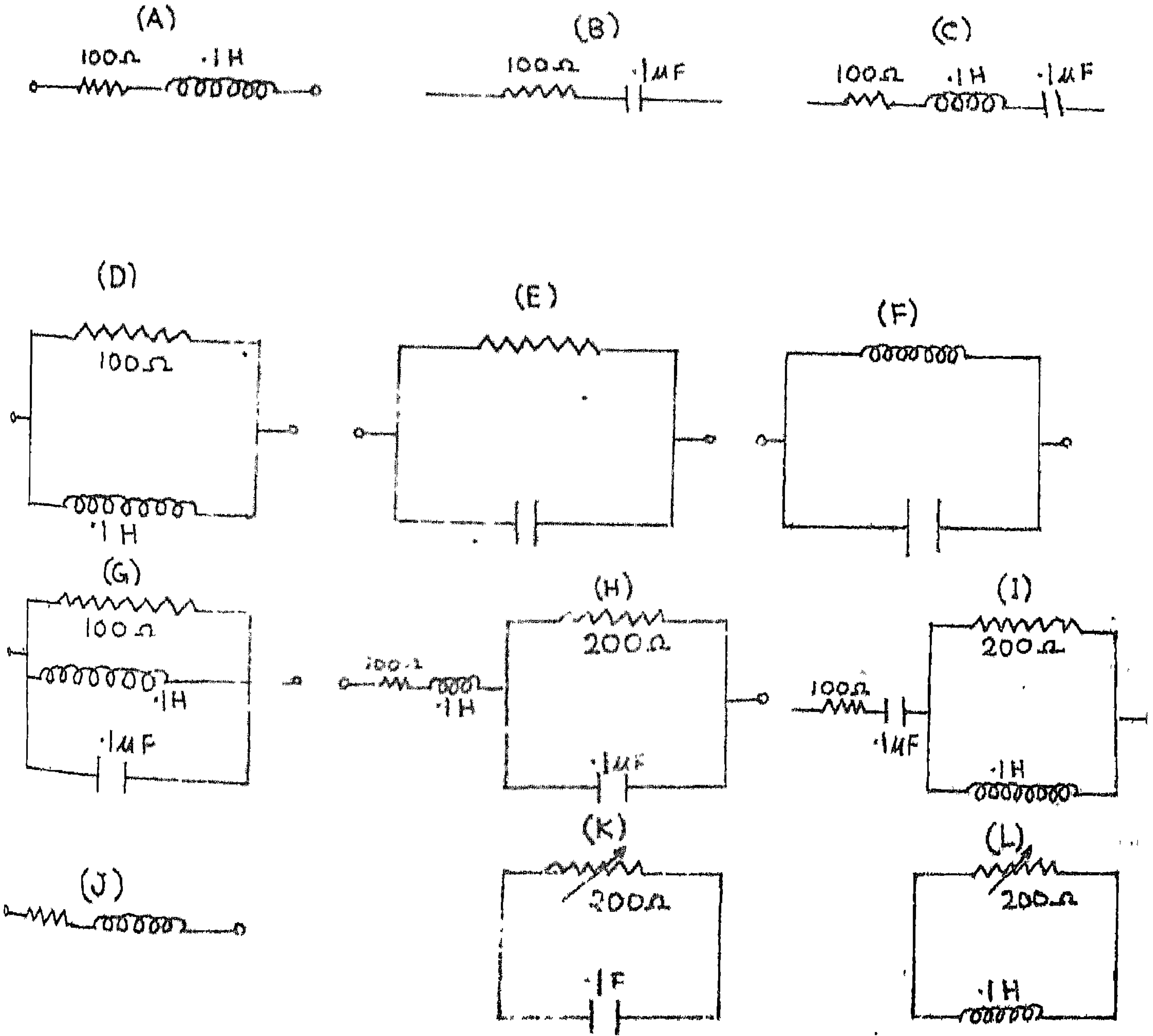


FIG 15.1

CIRCUIT DIAGRAM



EACH TO BE CONNECTED ACROSS 2-2'

FIG 15.2

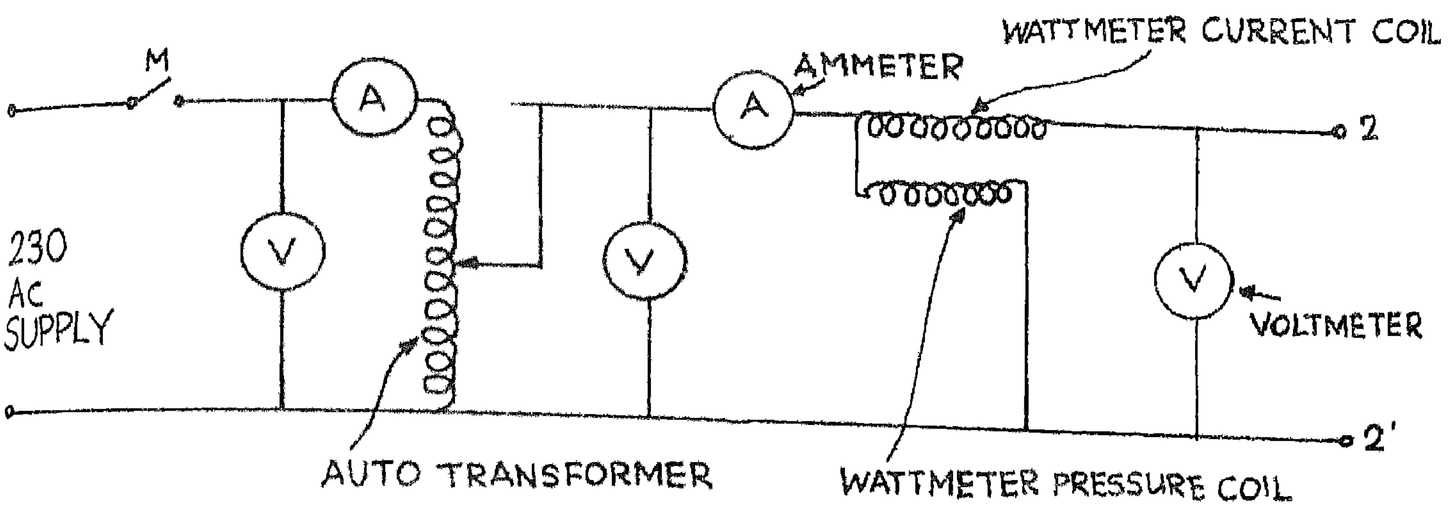
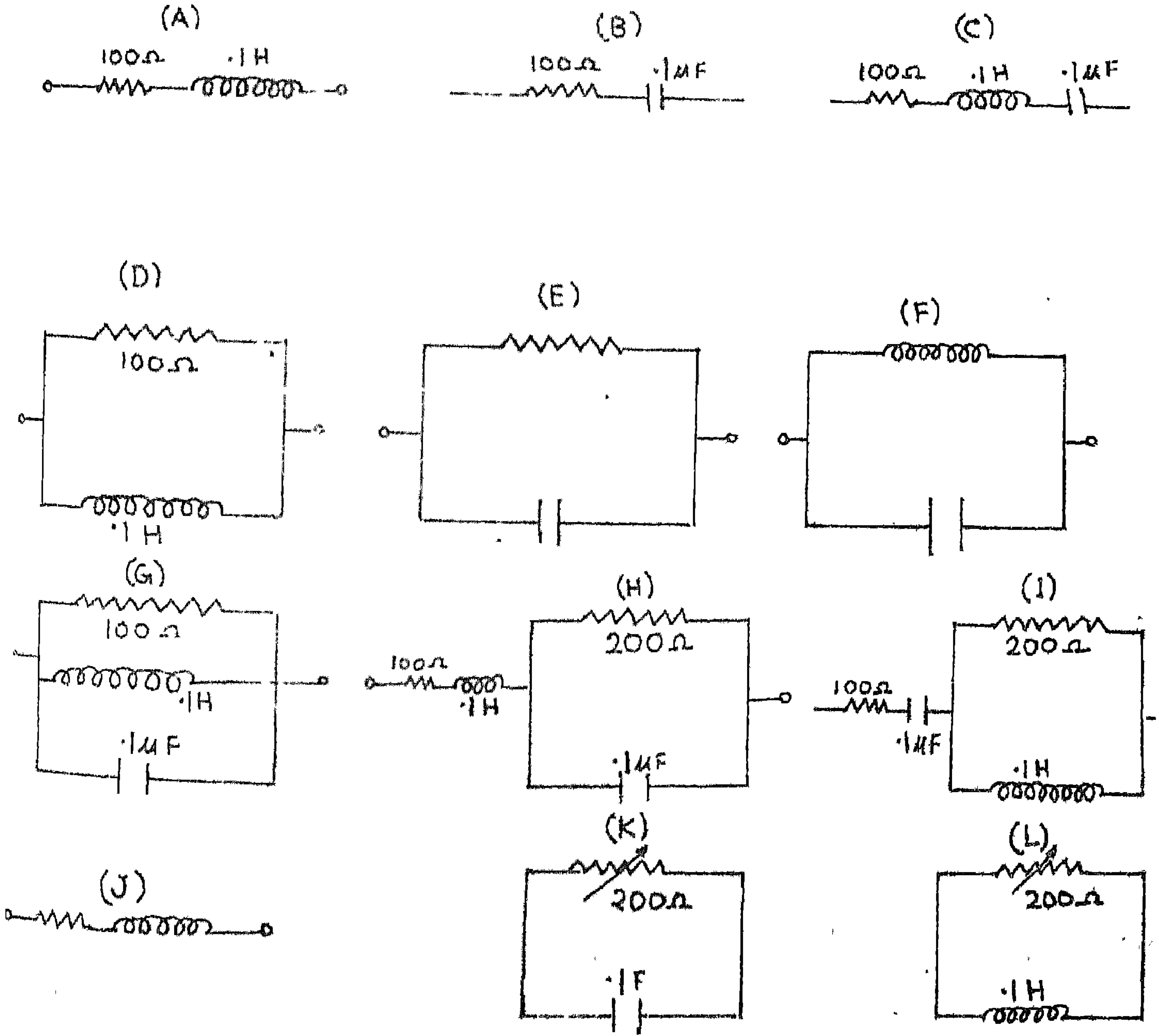


FIG 15.1

CIRCUIT DIAGRAM



EACH TO BE CONNECTED ACROSS 2-2'

FIG 15.2

Experiment No: 16(a)

1. Title of Experiment: To study resonance in R-L-C. series circuit.

2. Specific Objectives:

/ resonance

To understand the phenomenon of / in A.C. electrical circuit.

To study the various characteristics curves for the resonant circuit.

To measure the voltages across L and C.

3. Introductory information and related theory:

Generally a series R.L.C. circuit offers an impedance which is partly resistive and partly reactive in nature. If the conditions are created such that the impedance is purely resistive in nature, Then the series R.L.C. circuit is said to be under resonant condition. This requires that the resultant reactance of the circuit should be zero. Refer Fig: 16.1 (a)

let X_L denote the inductive reactance and X_c denote the capacitive reactance then $X_L = 2\pi f L$

and $X_c = \frac{1}{2\pi f C}$ ohms.

where L is the inductance in henry, C is the capacitance in farads and f is the supply frequency in Hertz.

Then for resonance to occur

$$X_L = X_C \text{ or } 2\pi f L = \frac{1}{2\pi f C} \quad \text{——} (1)$$

The above equation indicates that the phenomena of resonance may be obtained by varying any of the following parameters.

1. The supply frequency (f)
2. The inductance of the circuit. (L)
3. The capacitance of the circuit (C)

If fo is the resonant frequency then

$$fo = \frac{1}{2\pi (LC)^{1/2}}$$

In this experiment the resonance is obtained by varying the supply frequency. The impedance of the circuit is minimum at resonance and is equal to the resistance of the circuit.

The other characteristic of the circuit at resonance are

1. The current is maximum.
2. The power factor is unity.
3. The voltages across the capacitor and the inductor are equal and each of them is much greater then the supply voltage.
4. The voltage across the resistor is equal to the supply Voltage.

Fig 16.2 (a) shows the variation of current with the frequency current

Fig 16.2.(a)

Experiment No: 16(a)

1. **Title of Experiment:** To study resonance in R-L-C. series circuit.

2. **Specific Objectives:**

To understand the phenomenon of resonance in A.C. electrical circuit.

To study the various characteristics curves for the resonant circuit.

To measure the voltages across L and C.

3. **Introductory information and related theory:**

Generally, a series R.L.C. circuit offers an impedance which is partly resistive and partly reactive in nature. If the conditions are created such that the impedance is purely resistive in nature., Then the series R.L.C. circuit is said to be under resonant condition. This requires that the resultant reactance of the circuit should be zero. Refer Fig: 16.1 (a)

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where L is the inductance in henry, C is the capacitan in farads and f is the supply frequency in Hertz.

Then for resonance to occur

$$X_L = X_C \text{ or } 2\pi f L = \frac{1}{2\pi f C} \quad \text{———} (1)$$

The above equation indicates that the phenomena of resonance may be obtained by varying any of the following parameters.

1. The supply frequency (f)
2. The inductance of the circuit. (L)
3. The capacitance of the circuit (C)

If fo is the resonant frequency then

$$fo = \frac{1}{2\pi (LC)^{1/2}}$$

In this experiment the resonance is obtained by varying the supply frequency. The impedance of the circuit is minimum at resonance and is equal to the resistance of the circuit.

The other characteristic of the circuit at resonance are

1. The current is maximum.
2. The power factor is unity.
3. The voltages across the capacitor and the inductor are equal and each of them is much greater than the supply voltage.
4. The voltage across the resistor is equal to the supply Voltage.

Fig 16.2 (a) shows the variation of current with the frequency current

Fig 16.2.(a)

The variation of other quantities with the frequency is shown in fig 16.3 (a)

Fig 16.3 (a)

4. Equipment and Materials:

1. Variable frequency generator (oscillator 0-10KHz)
2. A variable resistor (0-100 ohms)
3. An inductor (1 millihenry)
4. A capacitor (100 micro farads)
5. Vacuum tube voltmeter (V.T.V.M.) - 3 Nos
6. A standard resistor (say 1 ohm)
7. Connecting wires.

5. Circuit Diagram:

Fig 16.4. (a)

6. Procedure:

1. Connect the variable resistor, the inductor and the capacitor to the variable frequency generator as shown in the figure 16.4 (a)
2. Set the value of resistance approximately at about 60 to 80 ohms.

3. Vary the frequency of the frequency generator from a low value to a high value and record the corresponding V.T.V.M. readings, V_1 and V_2

4. Repeat the procedure for different values of resistances.

5. Plot the characteristic between frequency and current on the semi-log graph paper.

6. Compute the resonant frequency.

7. Measure the voltages across the capacitor and the inductor.

7. Tabular Record of Observations:

S.No.	Value of Resistance	V_1	Frequency (f)	Current $I=V_2/r$	V_L	V_C	Remark
1							
2	Say R=60 ohm						fo
3							

S.No.	Value of Resistance	V_1	Frequency (f)	Current $I=V_2/r$	V_L	V_C	Remarks
1							
2	R=40 Ohm						fo=
3							
1							
2	R=20 ohm						f=o
3							

R-L-C SERIES CIRCUIT

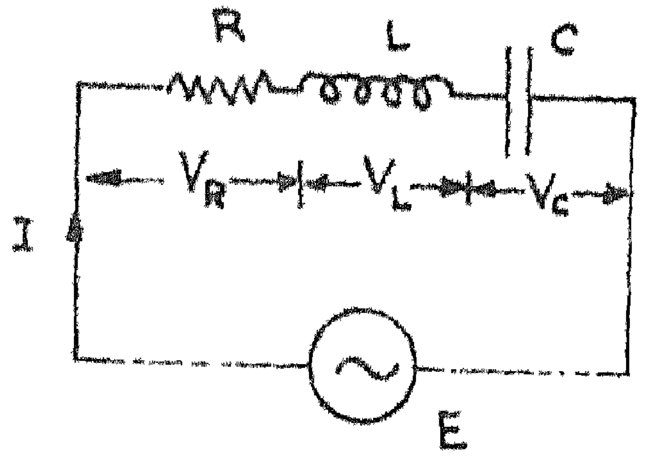


FIG 16.1 (a)

VARIATION OF I WITH f

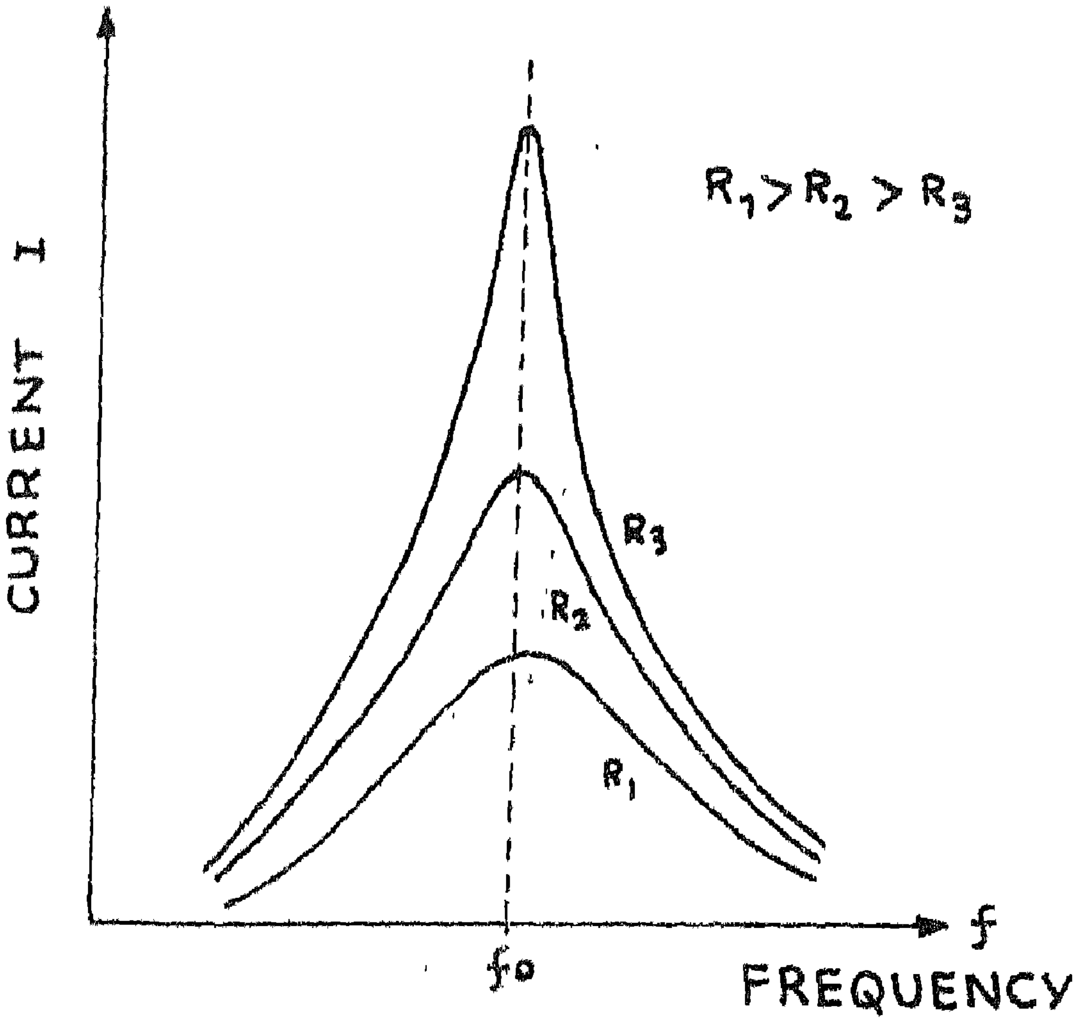


FIG 16.2 (a)

VARIATION OF Z, R, X_L, X_C AND POWER FACTOR WITH f

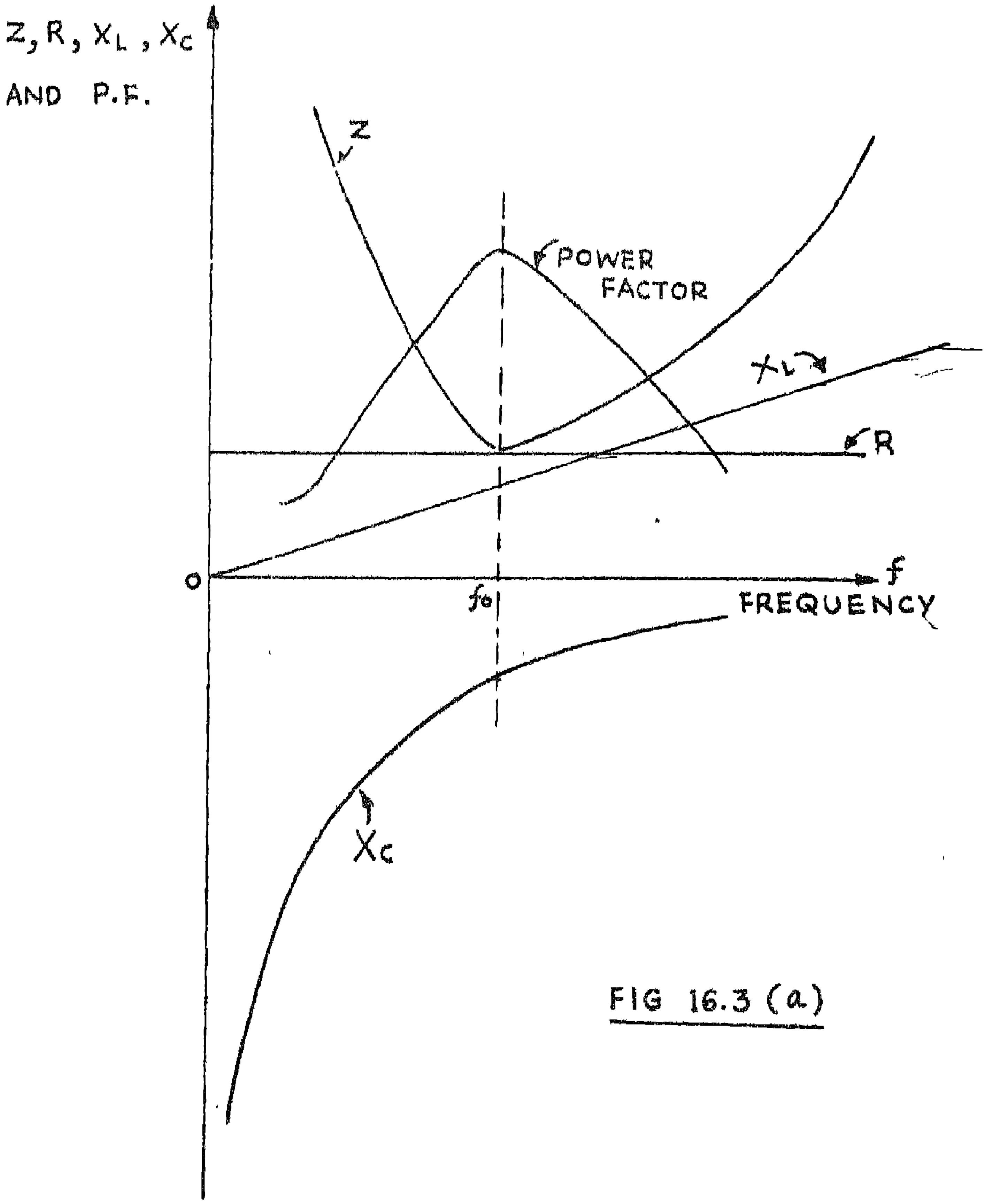
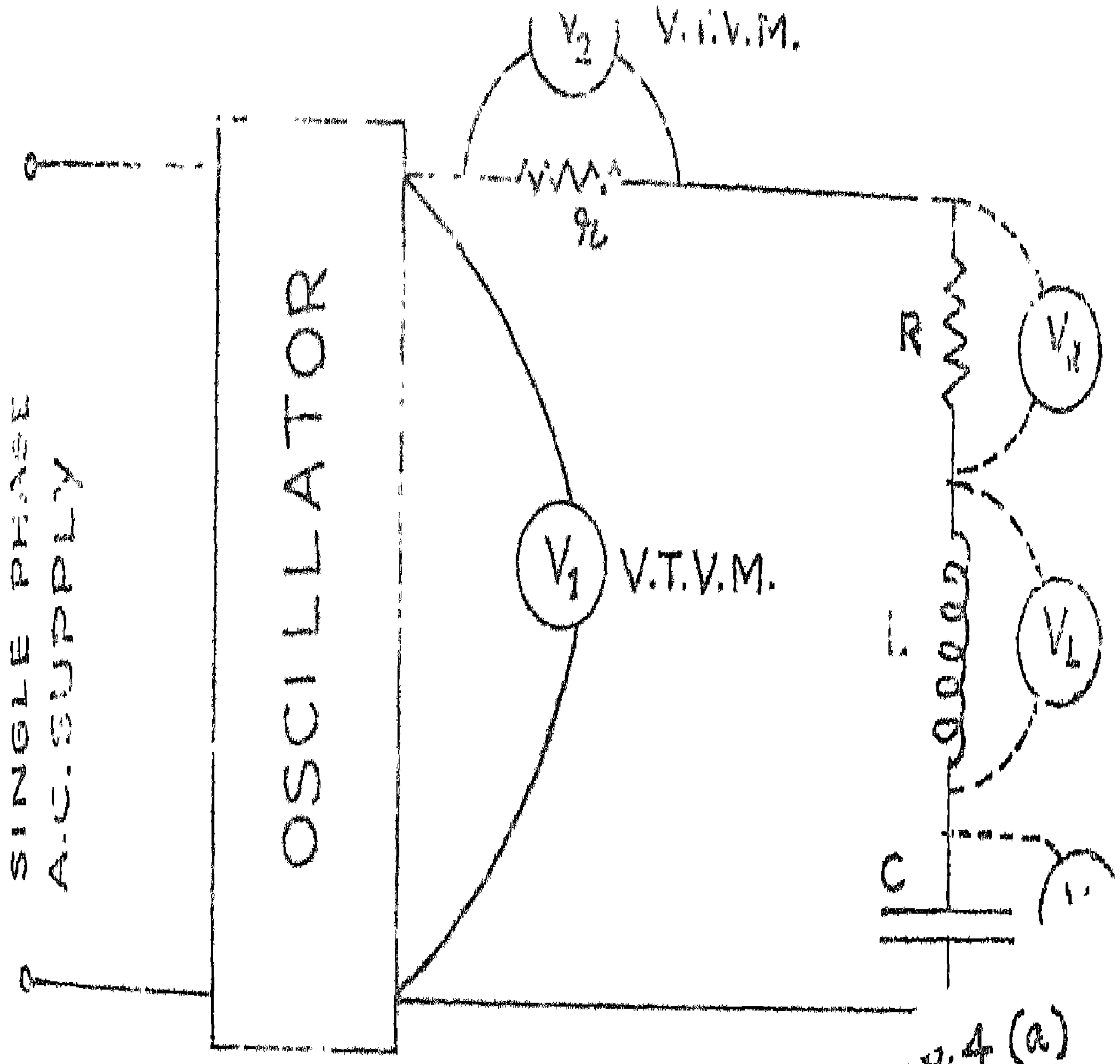


FIG 16.3 (a)



.g.4 (a)

8. Precautions:

1. All connections should be tight.
2. At resonance the current is maximum so care should be taken that the current at resonance should not exceed the maximum range of the current.
3. The voltages across capacitor and inductor is also high so the voltmeter should be chosen of appropriate range.

9. Questions for evaluation:

1. What are the applications of a series resonant circuit ?
2. How does the inductive reactance vary with the frequency ?
3. How does the capacitive reactance vary with the frequency ?
4. What is the power factor at resonance ?
5. Why the current is maximum at the resonance ?
6. Why do you use V.T.V.M. and the standard resistor for the measurement of circuit current ?
7. Can you measure this current by an ordinary a.c. ammeter ? If so, what are the errors in measurement?

Experiment No. 16 (b)

1. **Title of the Experiment:**

   To study resonance in a parallel circuit.

2. **Specific Objectives:**

   1. To study the phenomena of resonance in an a.c. parallel circuit.
   2. To study the characteristics of resonance.

3. **Introductory Information and Related theory:**

When a capacitor is connected in parallel with a R-L series circuit, then generally the impedance offered by such a combination consists of partly resistive and partly reactive in nature.

However, conditions may be created when the impedance is purely resistive in nature. This condition is called the resonant condition.

This may be achieved by

1. Varying the frequency of supply (f)
2. Varying the inductance (L)
3. Varying the capacitance (C)

Refer Fig 16.1. (b)

A R-L series circuit is connected in parallel with a capacitor C

Fig 16.1 (b)

The combination is connected to a variable frequency source (an **Oscillator**)

Let V be the supply voltage in volts

I be the resultant current in amps.

I_L be the current through R-L series combination.

I_C be the current through the capacitor.

Referring the Vector diagram of fig 16.2 (b)

The supply voltage V represents the reference vector. I_L lags V by an angle ϕ, where $\phi = \tan^{-1} \frac{X_L}{R}$

Here $X_L = 2\pi f l$, for any given value of the frequency f.

I_c leads V by 90°

The vector sum of I_L and I_C is equal to I, the current drawn from the supply mains. Under resonant conditions the impedance offered by the entire circuit is purely resistive in nature so that I lies in the same phase as that of V. This is possible when

$I_c = I_L \sin \phi$ (1)

Let fo be the resonant frequency in Hertz. Then the capacitive reactance $X_c = \frac{1}{W_oC}$ and the inductive reactance = WoL

Where Wo = 2 π fo L

$$I_c = \frac{V}{x_c} = V.\ WoC$$

$$\text{and } I_L \sin \emptyset/ = \frac{V}{\sqrt{R^2 + Wo^2 L^2}} \times \frac{WoL}{\sqrt{R^2 + Wo^2 L^2}}$$

$$= \frac{V.\ WoL}{R^2 + Wo^2 L^2}$$

Equation (1) may then be rewritten as

$$V\ Wo\,c = \frac{V.\ WoL}{R^2 + Wo^2 L^2}$$

This requires that for resonance to occur

$$Wo\,c = \frac{WoL}{R^2 + Wo^2 L^2} \qquad (2)$$

From equation (2) the value of Wo may be calculated.

$$Wo = \frac{1}{L} (L/c - R^2)^{1/2}$$

and the resonant frquency fo is

$$fo = \frac{1}{2\pi L}\sqrt{\frac{L}{C} - R^2} \qquad (3)$$

If R is very small compared to L, then it may be ignored compared to L. under this conditions

$$fo = \frac{1}{2\pi\sqrt{LC}} \qquad (4)$$

Equation (4) is valid for R-L-C series resonance also.

Hence if the resistance (R) is negligible then the expression for resonant frequency is same for series and parallel circuits. The following are the properties of parallel resonant circuit.

i) The impedance of the circuit is maximum.

ii) The current (I) drawn from the supply mains is minimum.

iii) The power factor of the circuit is unity.

iv) The currents I_C and I_L are much larger than the current I.

The quantity $\frac{X_L}{Z_L^2} = \frac{WoL}{R^2 + Wo^2 L^2}$ is called inductive susceptance B_L.

Similarly $\frac{X_c}{X_c^2} = \frac{1}{X_c} = WoC$ is called capacitive susceptance (B_C) for very small value of R

$$B_L \propto \frac{1}{L}$$

$$B_C \propto C$$

The variation of various quantities are shown in fig 16.3 (b)

Fig 16.3 (b)

4. Equipment and Materials:

1.	Variable frequency generator (Oscillator.	1 No.
2.	Vacuum tube voltmeter (V.T.V.M.)	2 Nos.
3.	Capacitor (8 micro F)	1 No.
4.	Inductor (choke coil) (20 m H)	1 No.
5.	A standard Resistor (1 ohm)	1 No.
6.	Connecting wires	

5. Circuit Diagram:

see diagram No 16.4 (b) attached.

6. Procedure:

1. Connect the circuit as shown in the figure 16.4 (b)
2. Start varying the frequency (f) of the oscillator and record the V.T.V.M. readings V_1 and V_2.
3. Calculate the resonant frequency (when the input current is minimum)

SERIES RESONANCE

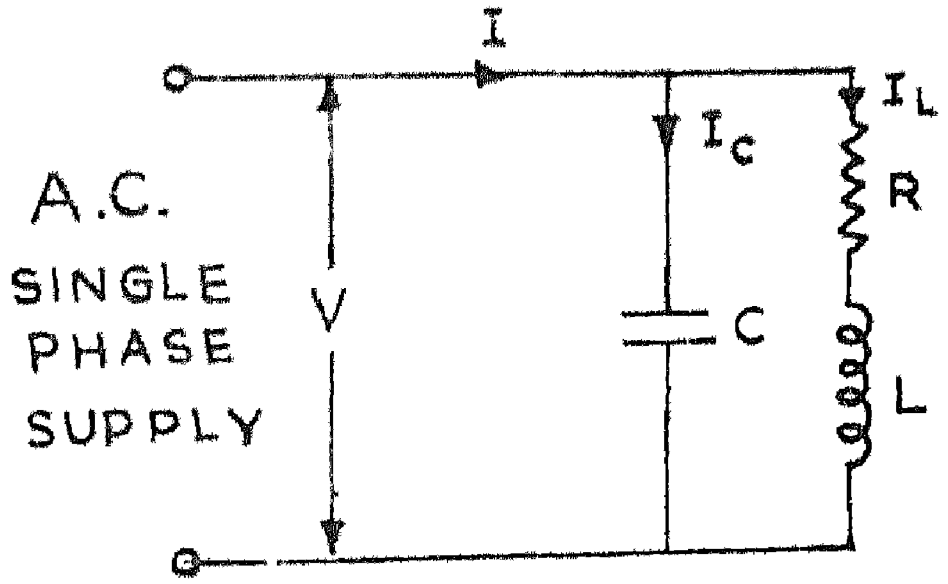


FIG 16.1 (b)

VECTOR DIAGRAM

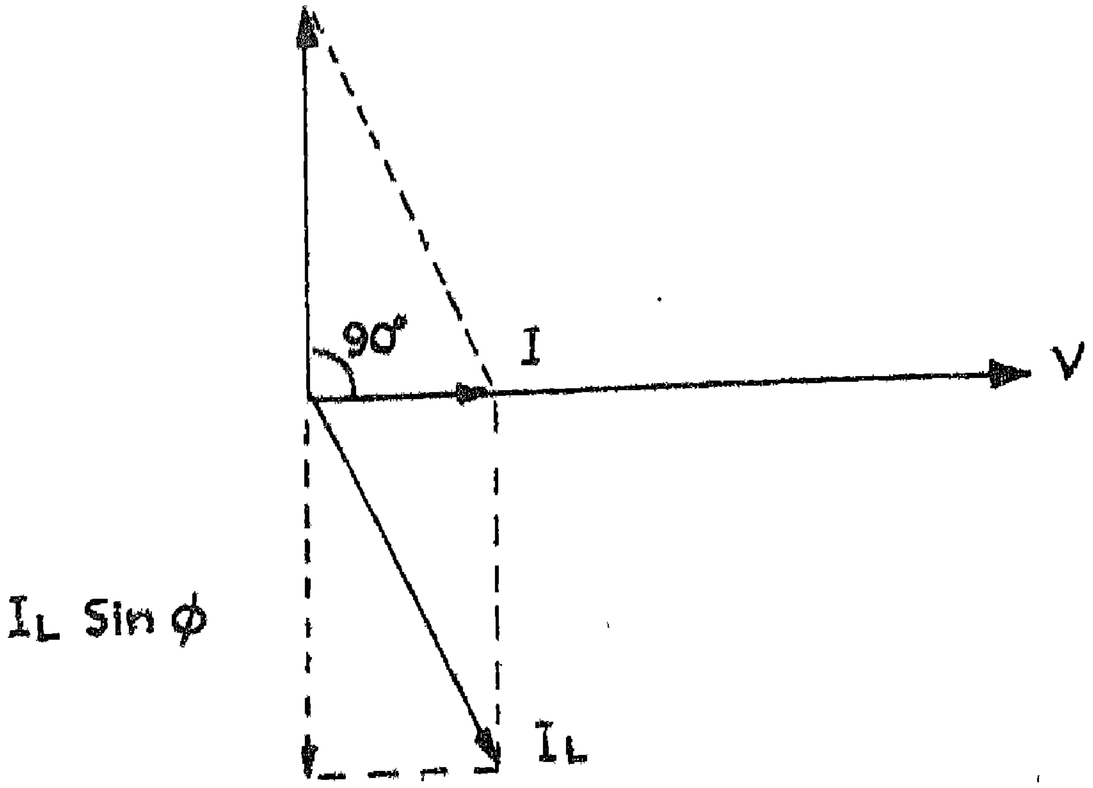


FIG 16.2 (b)

PARALLEL RESONANCE HARACTERISTICS

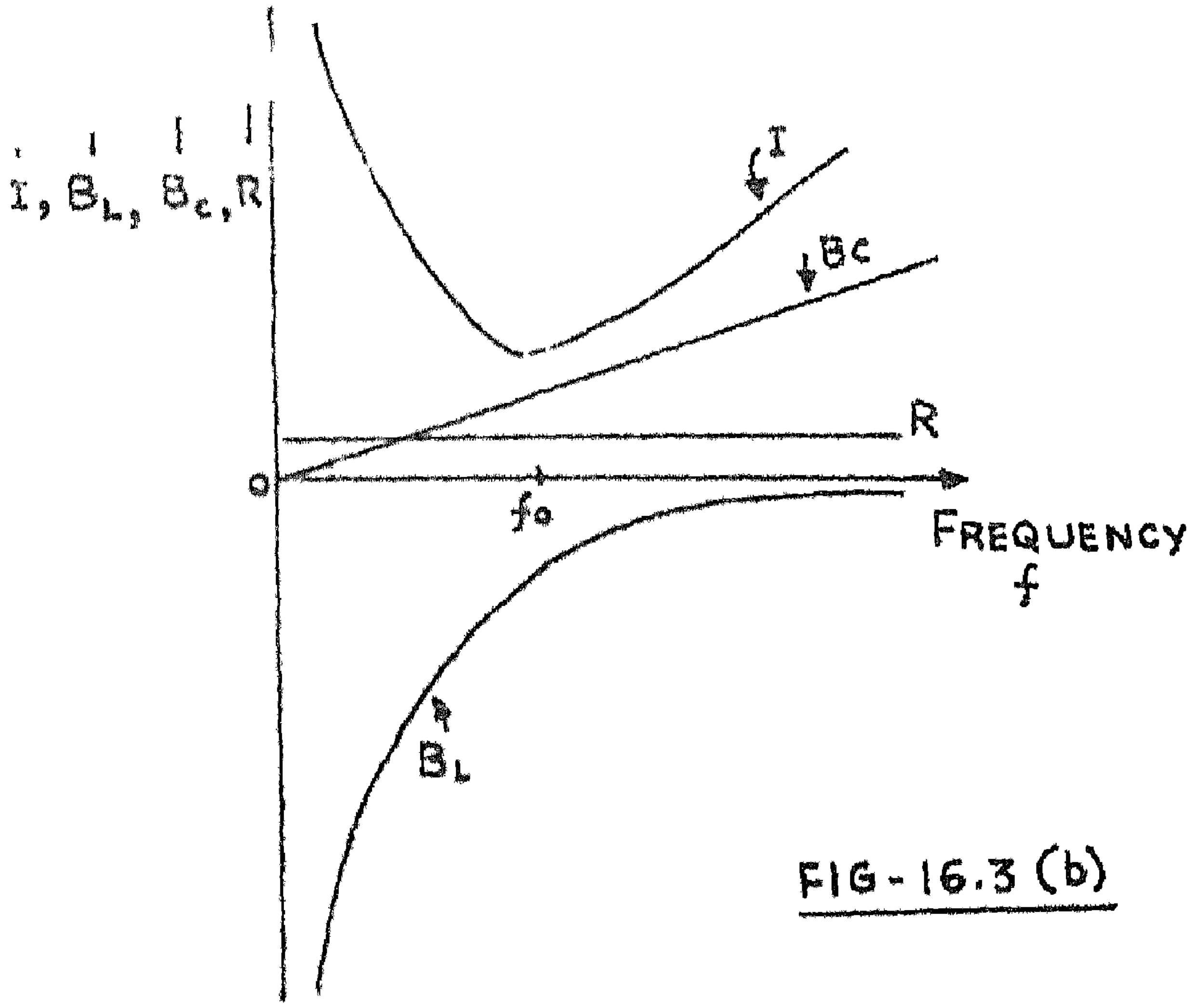


FIG-16.3 (b)

CIRCUIT DIAGRAM

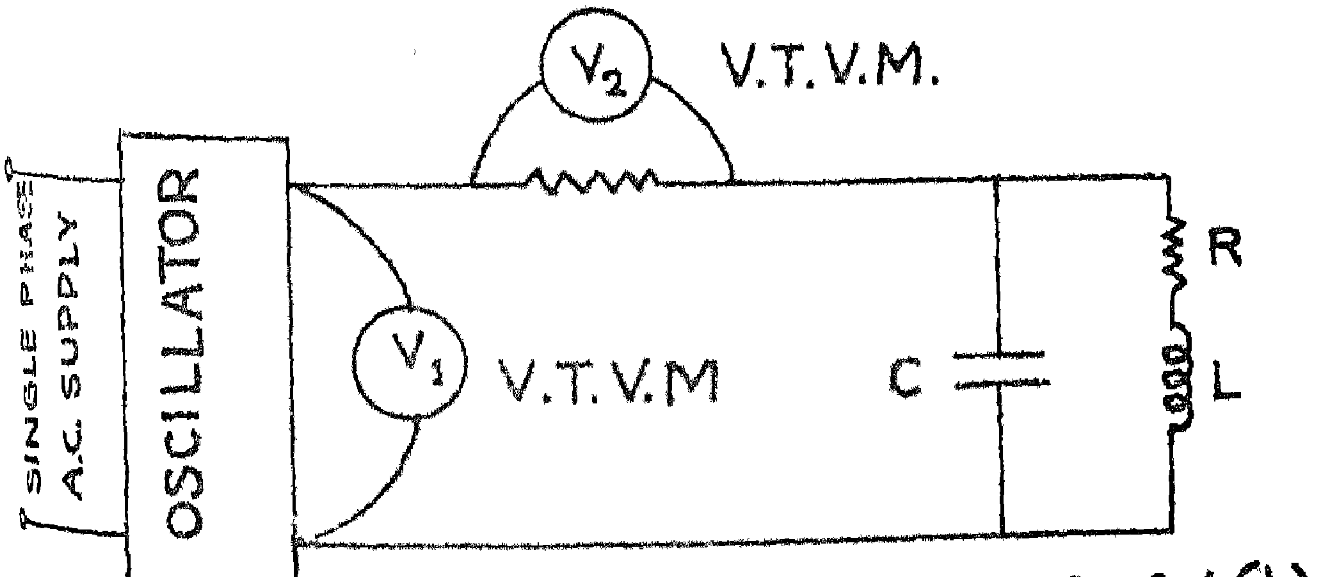


FIG 16.4(b)

7. Tabular Record of Observations :

S.No.	Frequency	V_1	V_2	$I = \frac{V^2}{r}$	Resonant freq (fo)

8. Precautions:

i) All connections should be tight,

ii) The inductor and capacitor should be of proper rating so that the resonance is obtained within the frequency range of the oscillator.

9. Questions for evaluation:

1. What is the practical signi-ficamnce of this experiment ?
2. Name the few applications where this type of resonance is used ?.
3. Why do we use V.T.V.M. for the measurement of the voltage rather than an ordinary voltmeter ?
4. In this experiment why the V.T.V.M. and standard resistor (r) is used to measure the current ? Can we measure the current tyrough a M.I. ammeter ?
5. What is the basic difference between series and the parallel resonance ?

References:-

Alternating current circuits by KERCHNER and CORCORAN

Experiment No. 17

1. Title of Experiment:

To verify Kirchhoff's Laws in series, Parallel & series parallel A.C. circuits.

2. Specific Objectives:

   1. To verify Kirchhoff's voltage law in a simple R-L series circuit.
   2. To verify Kirchhoff current law in a simple R & L parallel circuit.
   3. To verify Kirchhoff's current law and Kirchhoff's voltage law in a series parallel circuit containing a resistance in series with a parallel combination of R-L and C circuit.

3. Introductory Information and Related Theory:-

There are two law enunciated by Kirchhoff.

   1. Kirchhoff's Current Law (KCL): This law states that in an a.c. circuit the vector sum of the currents at a junction is zero.
   2. Kirchhoff's voltage law (KVL): This law states that in any closed a.c. electrical path the vector sum of potential drops and the potential rise is zero.

R-L Series circuit

Fig 17.1

In the figure 17-1, E represents the RMS value of the voltage applied, I represents the RMS value of current flowing through R.L. series circuit.

Let V_R represent the voltage drop across R.

and V_L represent the voltage drop across L

then V_R = IR volts

and V_L = IX_L volts

Where $X_L = 2\pi f L$ ohms

Referring to the vector diagram in fig 17.2

Fig. 17.2

Vector V_R is in the same phase as that of I and vector I lags behind vector V_L by 90^0.

The vector sum of V_R and V_L is represented by the vector OA. According to KVL, vector OA = E

R and L parallel circuit

Fig. 17-3

Refer fig. 17.3

I_R represents the current flowing through R.

I_L represents the current flowing through L.

I is the resultant current of the circuit.

Referring to fig. 17.4, the same voltage E is applied across R and L.

I_R is inthe same phase as that of E.

I_L lags behind E by 90^0.

Vector representation of E, I_R, I_L and I is shown in

Fig 17.4

The vector sum of I_R and I_L is equal to the resultant current I.

Series-parallel circuit

Fig. 17.5

Referring to figure 17.5

R_I and L are connected in series.

The R_I - L combination is connected in parallel with the capacitor C.

The resistance R_2 is connected in series with the above mentioned parallel circuit.

Let E be the voltage applied across the entire circuit.

I be the resultant current.

V_1 be the voltage drop across the parallel combination

V_2 be the voltage drop across resistance R_2

I_L be the current through R_1-L series combination.

I_C be the current through capacitance C.

Now referring to the vector diagram of fig. 17.6

Fig. 17.6

The KCL shows that the vector sum of I_L and I_C should be equal to the vector I. Also KVL shows that the vector sum of V_1 and V_2 should be equal to the Vector E.

4, Equipment and Materials

1. An autotransformer (Variac) (o-250V,5A)
2. M.I. Voltmeter (0.250 V) 3 Nos.
3. M.I. ammeter (0- 5A) 3 No.
4. One resistor (100 ohm, 10A) 1 No.
5. One inductor (100 mH) 1 No.
6. One capacitor .1 micro F, 5A) 1 No.

Circuit Diagram:

1. R-L series circuit Fig 17.7 attached
2. R and L parallel circuit Fig 17.8 attached
3. Series parallel circuit Fig 17.9 attached

6. Procedure:

R-L Series Circuit

1. Make the circuit as shown in circuit diagram in fig 17.7
2. Keep the variable point of the variac at zero.
3. Switch on the Supply.
4. Increase the output voltage to say 30 to 40 volts. take the observations of $V_1 V_R, V_2$ and I
5. Repeat the process at a step of 10 volts, & take 3 or 4 set of observations.

R & L paralled circuit

6. Make the circuit as shown in fig. 17.8

7. Repeat the process ii) & iii)

8. Keep the variac setting at nearly 30 to 40 volts and record the readings of V, I, I_R & I_L

9. Repeat the process for different voltages at 10 v steps.

Series Parallel Circuit.

10. Make the connections as shown in fig. 17.9

11. Repeat the process ii) & iii)

12. Apply nearly 30 to 40 Volts through the variac.

13. Record the readings V, V_1, V_2 , I, I_L, I_C.

14. Repeat the process for different voltages in a step of 10 volts.

7. Tabular Record of Observations:

For R-L series Circuit

S.No	V	I	V_R	V_L
1				
2				
3				

R & L in Parallel Circuit.

S.No.	V	I	I_R	I_L

Series-Parallel Circuit

S.No.	V	V_1	V_2	I	I_L	I_C

8. Precautions:-

1. All connections should be tight.
2. Before Switching on the supply the Variac setting should be at zero.

9. Questions for Evaluation:

1. What is the practical significance of this experiment ?
2. In R-L circuit, Why don't the voltage drops V_R & V_L Numerically add up equal to V ?

3. If R-L circuit is replaced by R-C circuit can you verify KVL ?

   Show how:

4. Explain the vector diagram and the circuit for verifying K V L through R-C circuit ?

5. What is the difference between algebraic addition and vector addition.

6. In R-L circuit what is the nature of power factor, can you improve this power factor. If so, How ?

7. In your series R & parallel (R-L and C) what is the over all power factor (Can you calculate this) suppose capacitor is removed, will the power factor improve or go low. State with reasons.

8. If a d-c voltage is applied across R-L circuits what impedance will be there. In case of R-C circuit, subjected to d.c. voltage will there be a flow of current ? Give reasons.

9. Give a useful application of a R-L circuit.

10. Reference:- Principles of A.C. circuits by

    KERCHNER AND CORCORAN.

CIRCUIT - DIAGRAMS

R-L SERIES CIRCUIT

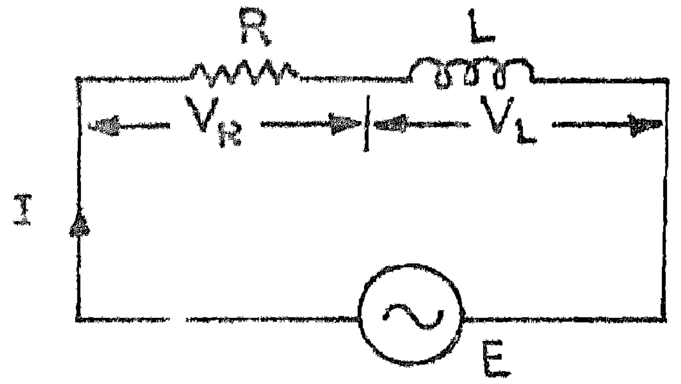


FIG 17.1

R AND L PARALLEL CIRCUIT

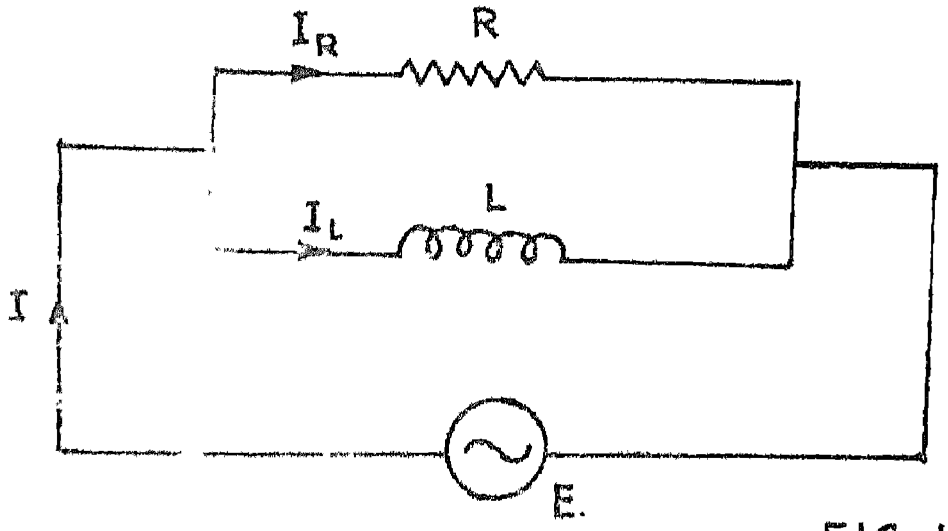


FIG 17.2

SERIES-PARALLEL CIRCUIT

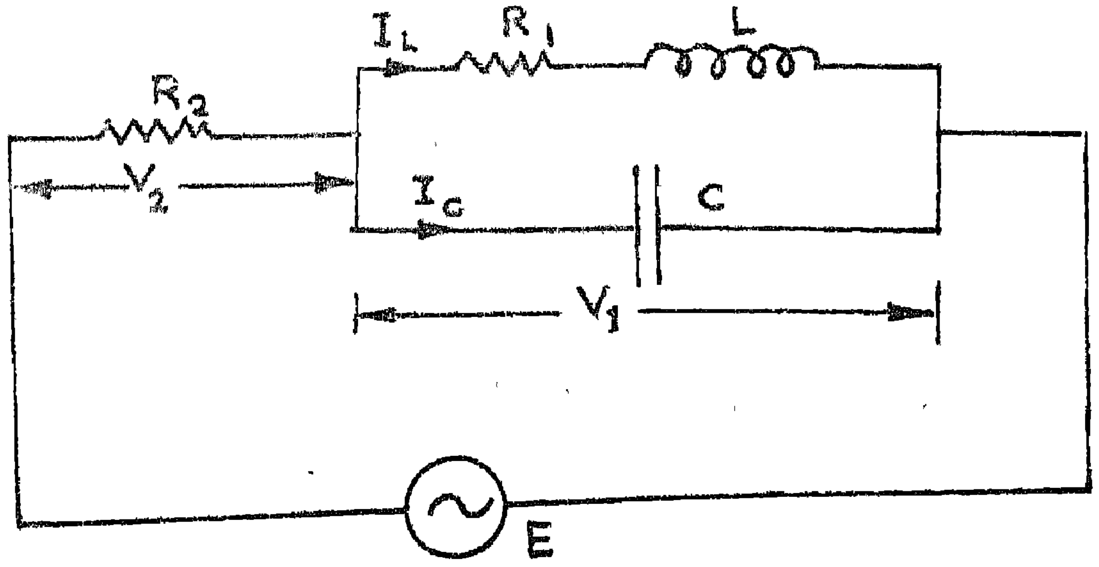


FIG 17.3

VECTOR - DIAGRAM

R-L SERIES CIRCUIT

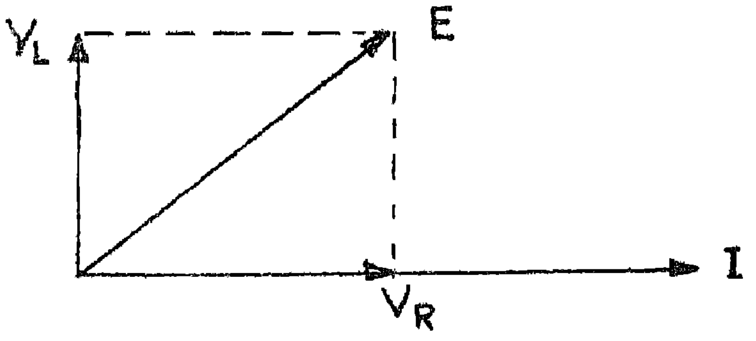


FIG 17.4

R AND L PARALLEL CIRCUIT

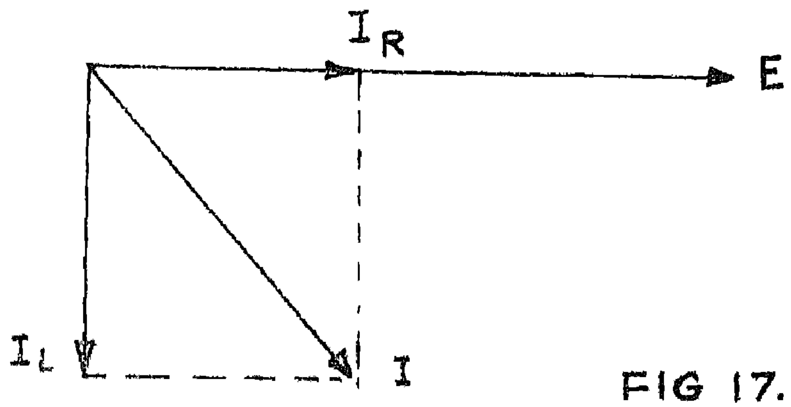


FIG 17.5

SERIES-PARALLEL CIRCUIT

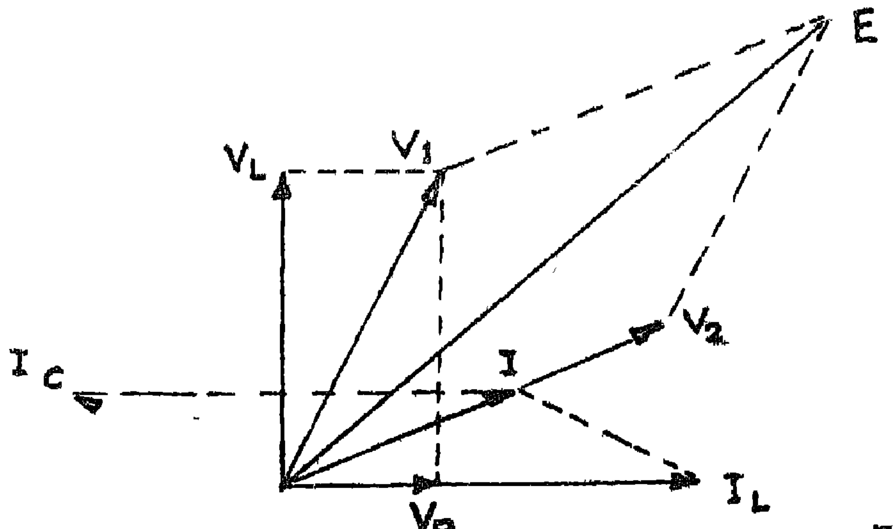


FIG. 17.6

R-L CIRCUIT

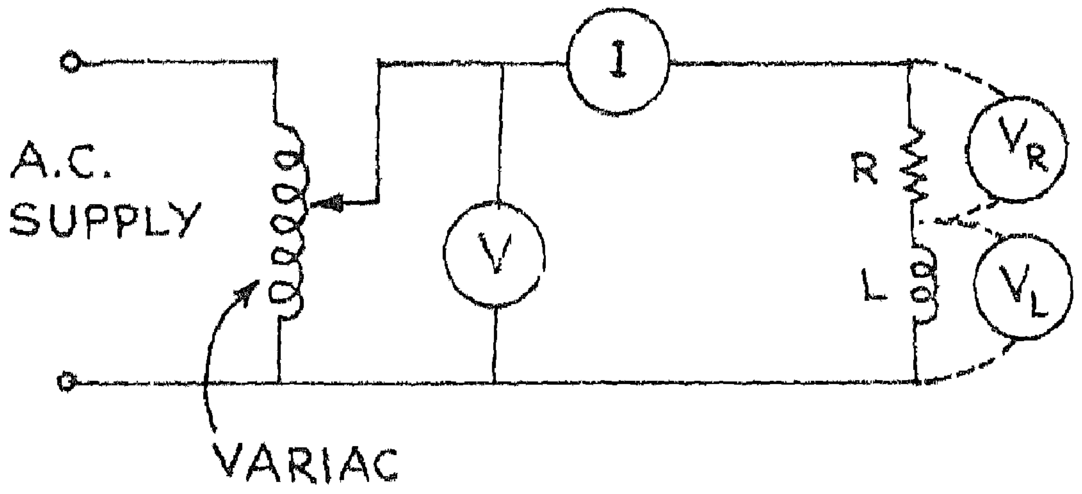


FIG 17.7

R AND L PARALLEL CIRCUIT

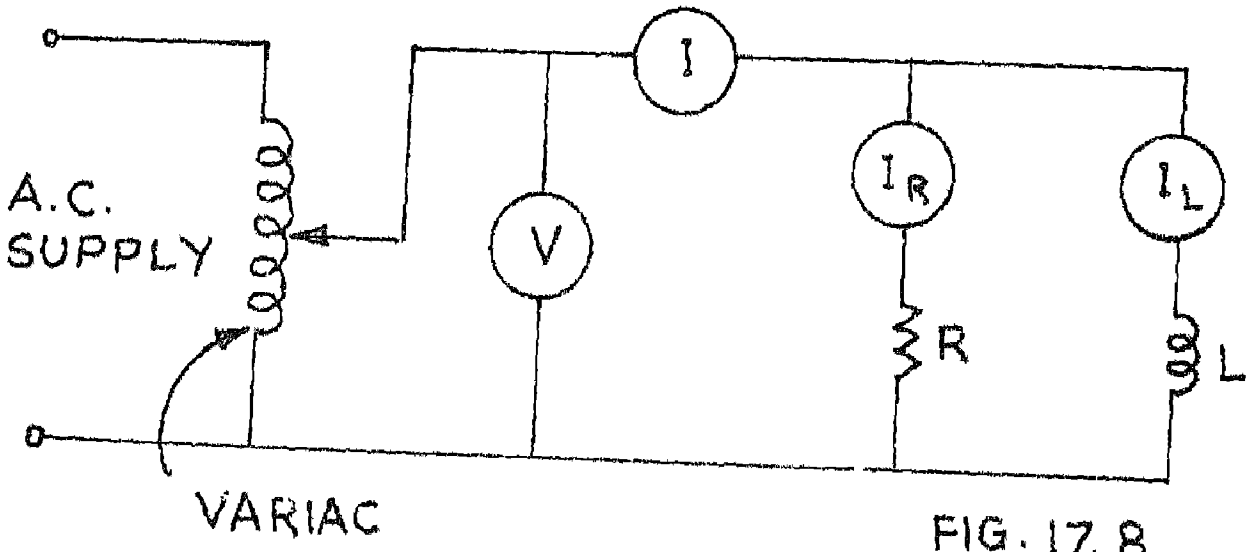


FIG. 17.8

SERIES-PARALLEL CIRCUIT

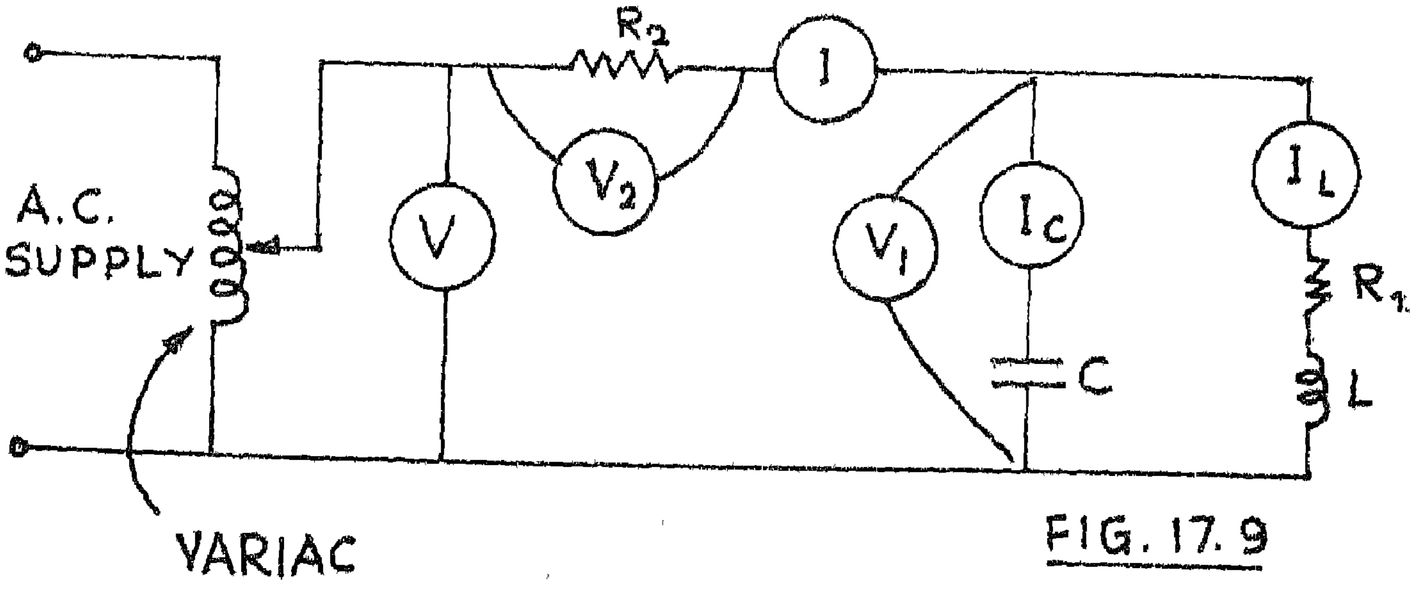


FIG. 17.9

Experiment No. 18

1. Title of the Experiment:

To study and measure voltages and currents in a three phase balanced star and delta circuits.

2. Specific Objectives:

i) To understand the load connection (say chokes or resistors) in a) star and b) in delta.

ii) To note the difference between the line and phase values of the voltages and currents.

iii) To verify the relations between the line values and the phase values of star and delta connected loads.

3. Introductory Information and Related Theory:

Three identical chokes or resistors may be connected in star or delta.

In star system of connection the voltages between the lines RY, YB and BR are called line voltages and the voltages between RN, YN and BN are known as phase voltages as shown in the figure 18.1.

Fig. 18.1

Star connection

Fig. 18.2

Delta Connection

In fig. 18.1

E_R, E_Y and E_B represent the phase voltages and E_{RY}, E_{YB}, E_{BR} are the line voltages.

For star connection in balanced loads as per fig. 18.3, the line voltage = $\sqrt{3}$ x phase voltage.

It may also be seen that the current which is flowing through a particular load resistance is also flowing in the same line.

Hence the line current = Phase current.

Referring to fig. 18.2

E_{RY}, E_{YB}, and E_{BR} are the voltages across the load. These are the phase voltages. Also the same voltages appear across the lines RY, YB and BR. This shows that the line voltages and phase voltages are same in the delta system of loads.

I_R, I_Y and I_B denote the line currents and I_{RY}, I_{YB} and I_{BR} denote the phase currents.

In a balanced delta connected load as per fig. 18.4 the line current = $\sqrt{3}$ phase current.

4. Equipment and Materials:

i) Three identical Resistors (100 ohms, 5A)
ii) Six M.I. type voltmeters (0-500 volts)
iii) Six M.I. type Ammeters (0-10 Amps)
iv) Connecting wires.
v) Three phase variac (400 V, 15A)

5. Circuit Diagram:

Star connection

Fig. 18.5

Delta connection

Fig. 18.6

6. Procedure:

i) Make the connections [illegible] fig. 18.5 and fig. 18.6.

ii) Mark the ammeters A1, A2, A3 ---------- A6 and voltmeters V1, V2, V3 ---------- V6.

iii) Switch on the [illegible].

iv) Record the readings [illegible] and voltmeters.

7. Tabular [illegible]:

V1, V2 and V3 represent [illegible].

V4, V5 and V6 represent [illegible].

A1, A2 and A3 represent [illegible].

A4, A5 and A6 represent [illegible].

Star connection

S.No.	A1	A2	A3	A4	A5	A6	V1	V2	V3	V4	V5	V6
1												
2												
3												

S.No.	Relation between	Remarks
1	A1 and A4	A1 and A4 are equal/not equal
2.	A2 and A5	A2 and A5 are equal/not equal
3.	A3 and A6	A3 and A6 are equal/not equal
4.	V1 and V4	V4 = 3 V1 / V4 3 V1
5.	V2 and V5	V5 = 3 V2 / V5 3 V2
6.	V3 and V6	V6 = 3 V3 / V6 3 V3

Delta connection

S.No.	A1	A2	A3	A4	A5	A6	V1	V2	V3	V4	V4	V6
1												
2												
3												

S.No.	Relation between	Remarks
1.	A1 and A4	$A4 = \sqrt{3}\,A1$ / $A4 \neq \sqrt{3}\,A1$
2.	A2 and A5	$A5 = \sqrt{3}\,A2$ / $A5 \neq \sqrt{3}\,A2$
3.	A3 and A6	$A6 = \sqrt{3}\,A3$ / $A6 \neq \sqrt{3}\,A3$
4.	V1 and V4	V1 and V4 are equal/not equal
5.	V2 and V5	V2 and V5 are equal/not equal
6.	V3 and V6	V3 and V6 are equal/not equal

8. Precautions

1. All connections should be tight.
2. The resistances used for star and delta connections should be equal in order to have balanced load.
3. Use instruments of proper ranges only

9. Questions for evaluation

1. What is the practical significance of this experiment ?
2. What is the phase and line relations for the star connection ?
3. What is the phase and line relations for the delta connection ?
4. If the values of the various resistances are not same do you expect the same relation between phase and line quantities to hold good as is valid under balanced condition ?

STAR CONNECTION

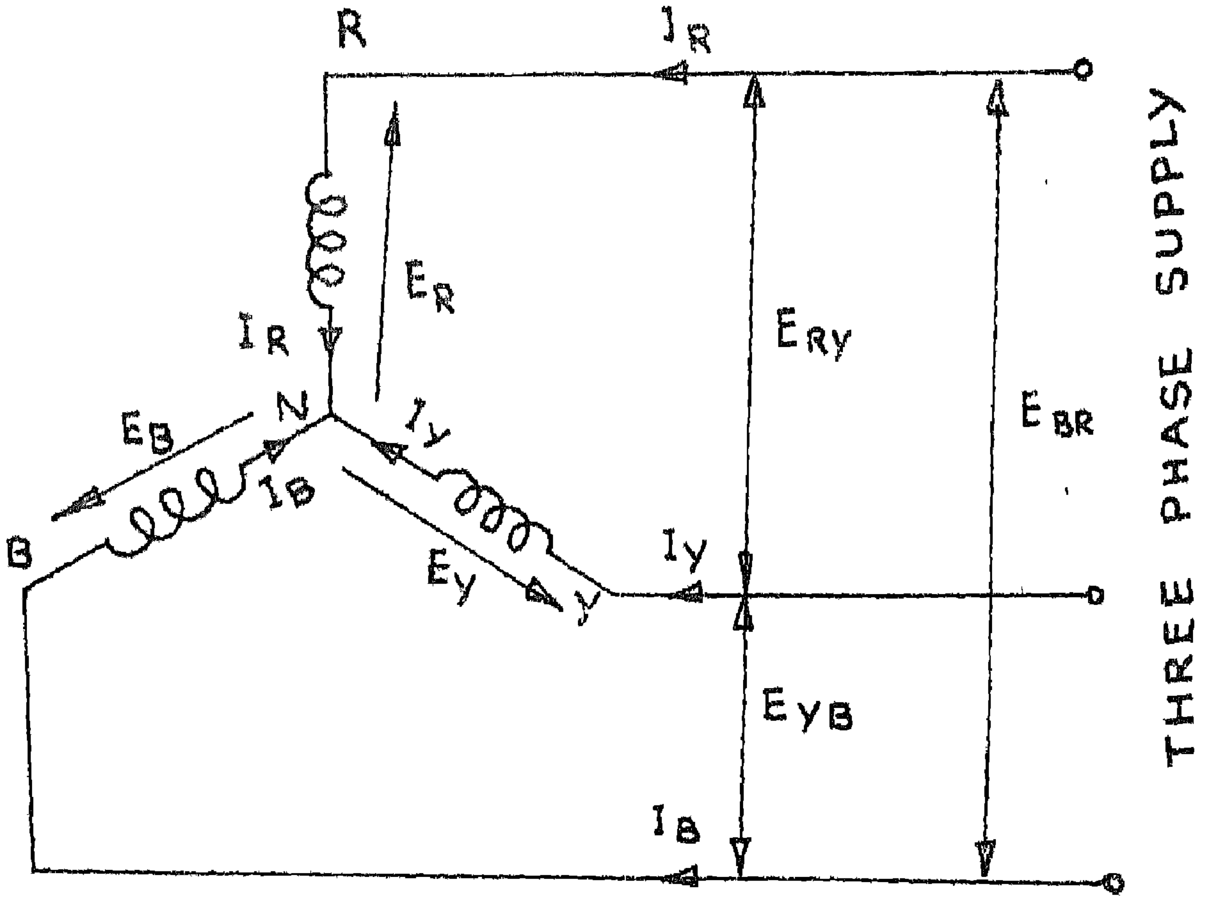


FIG 18.1

DELTA - CONNECTION

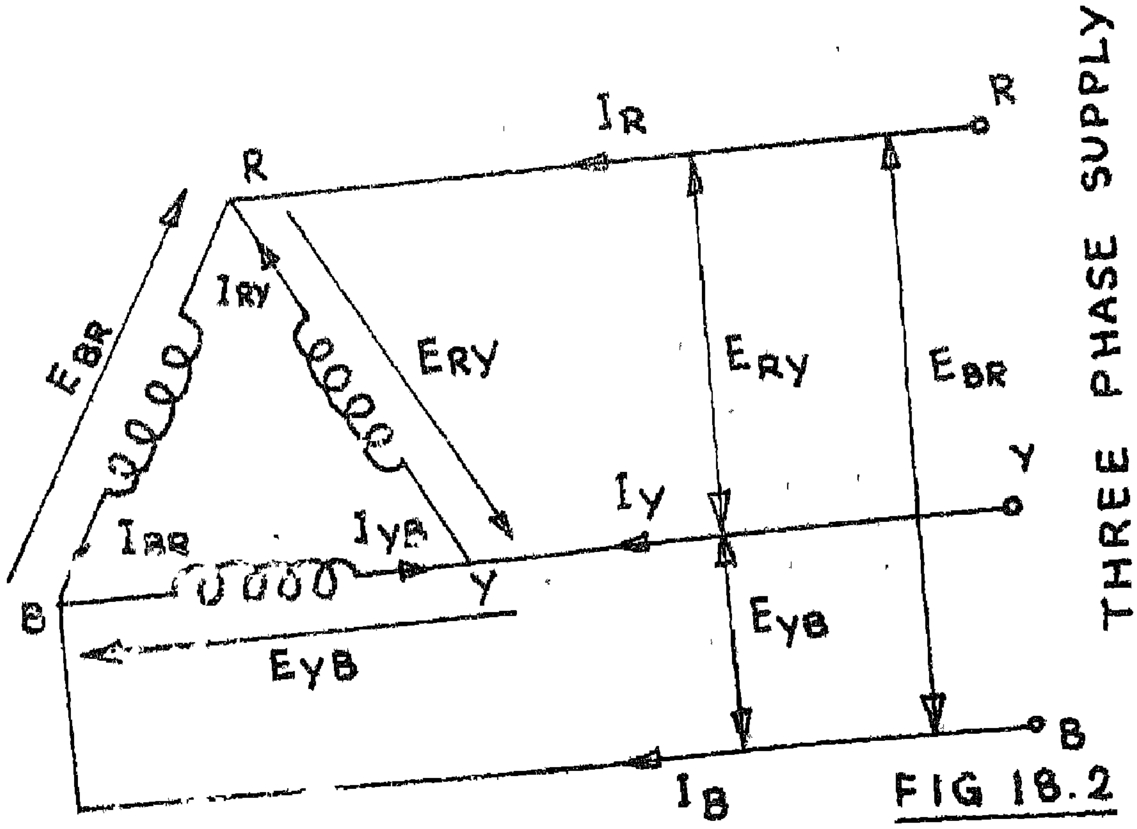
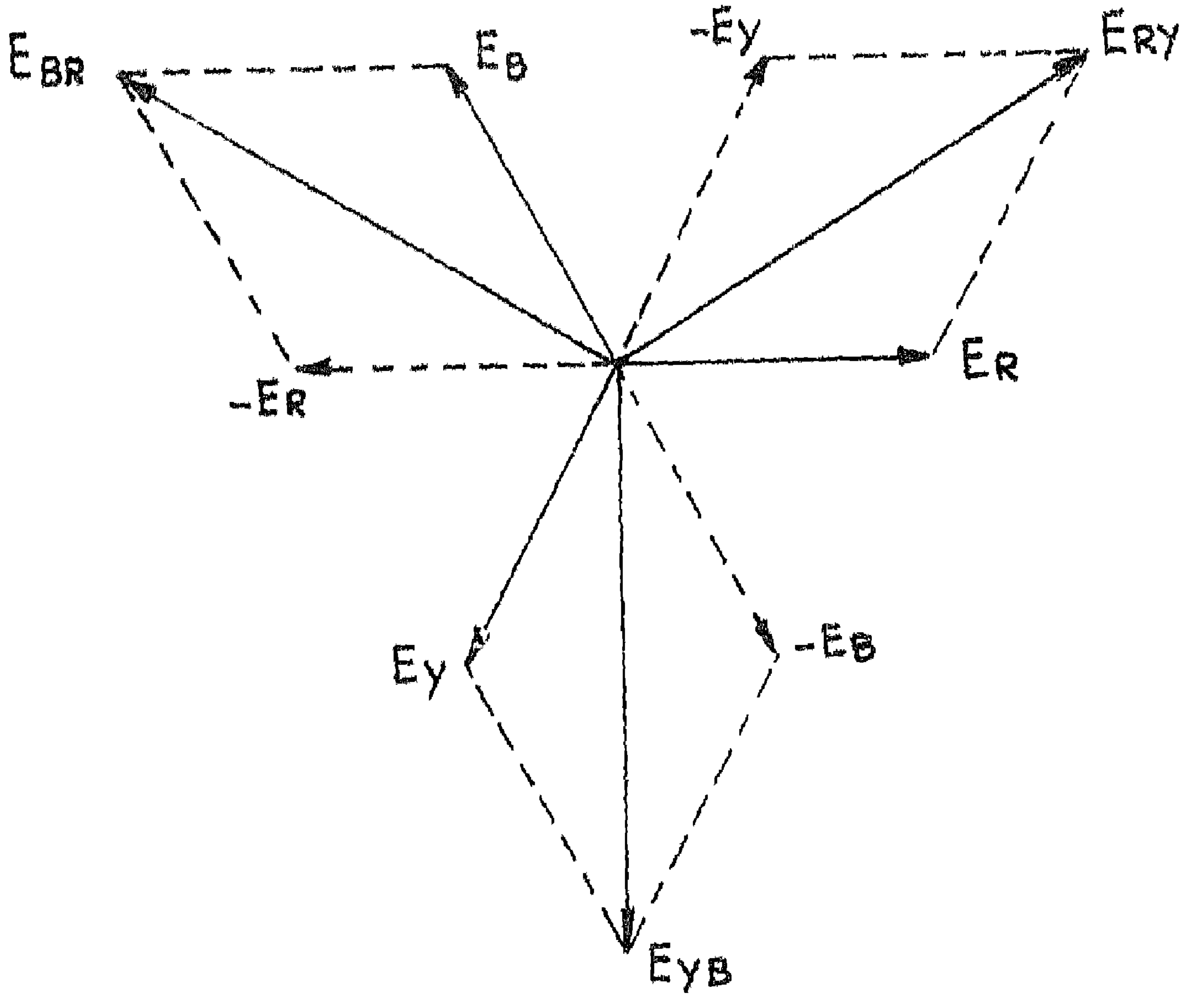


FIG 18.2

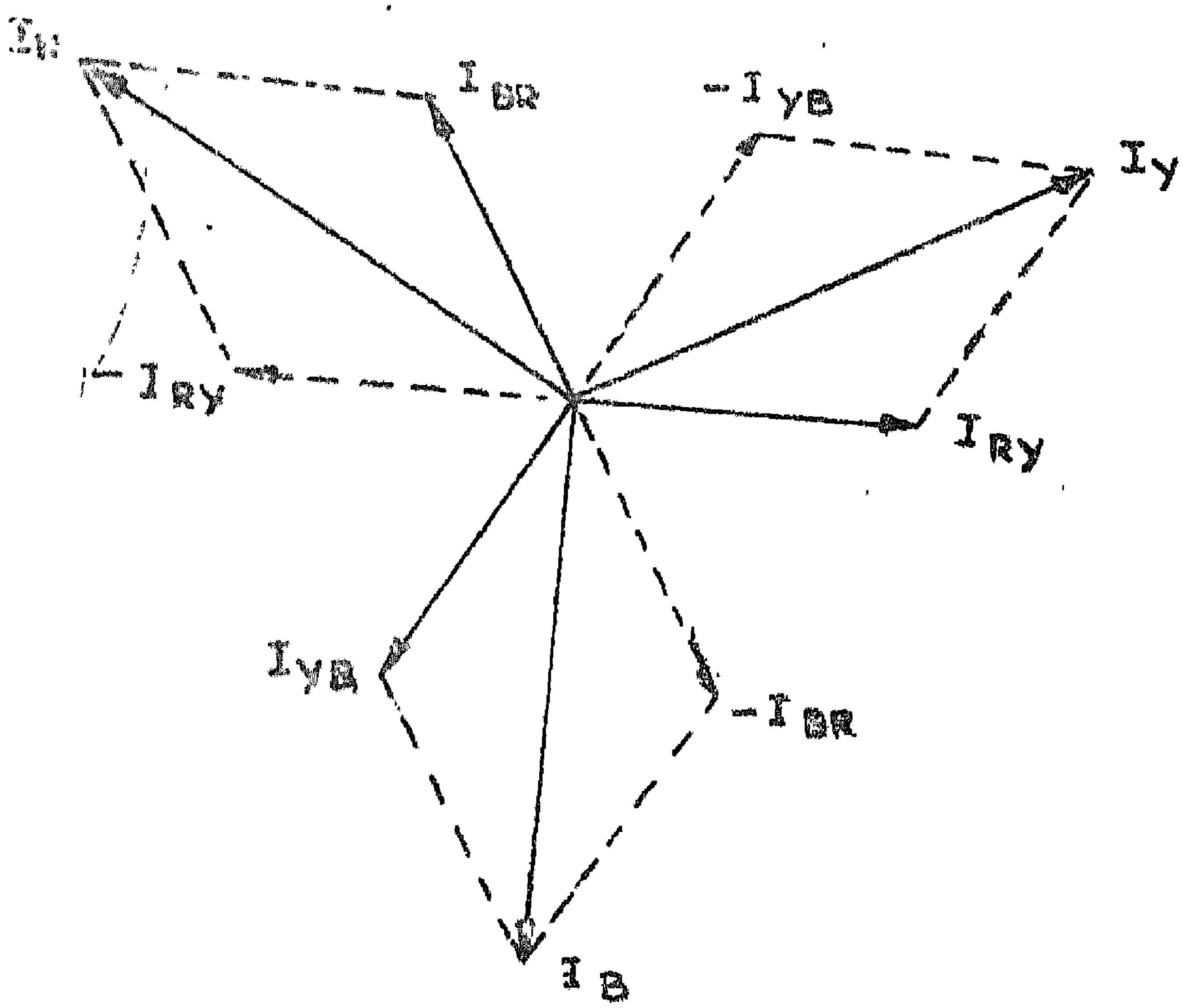
VECTOR DIAGRAM



STAR CONNECTION

FIG 18·3

VECTOR DIAGRAM

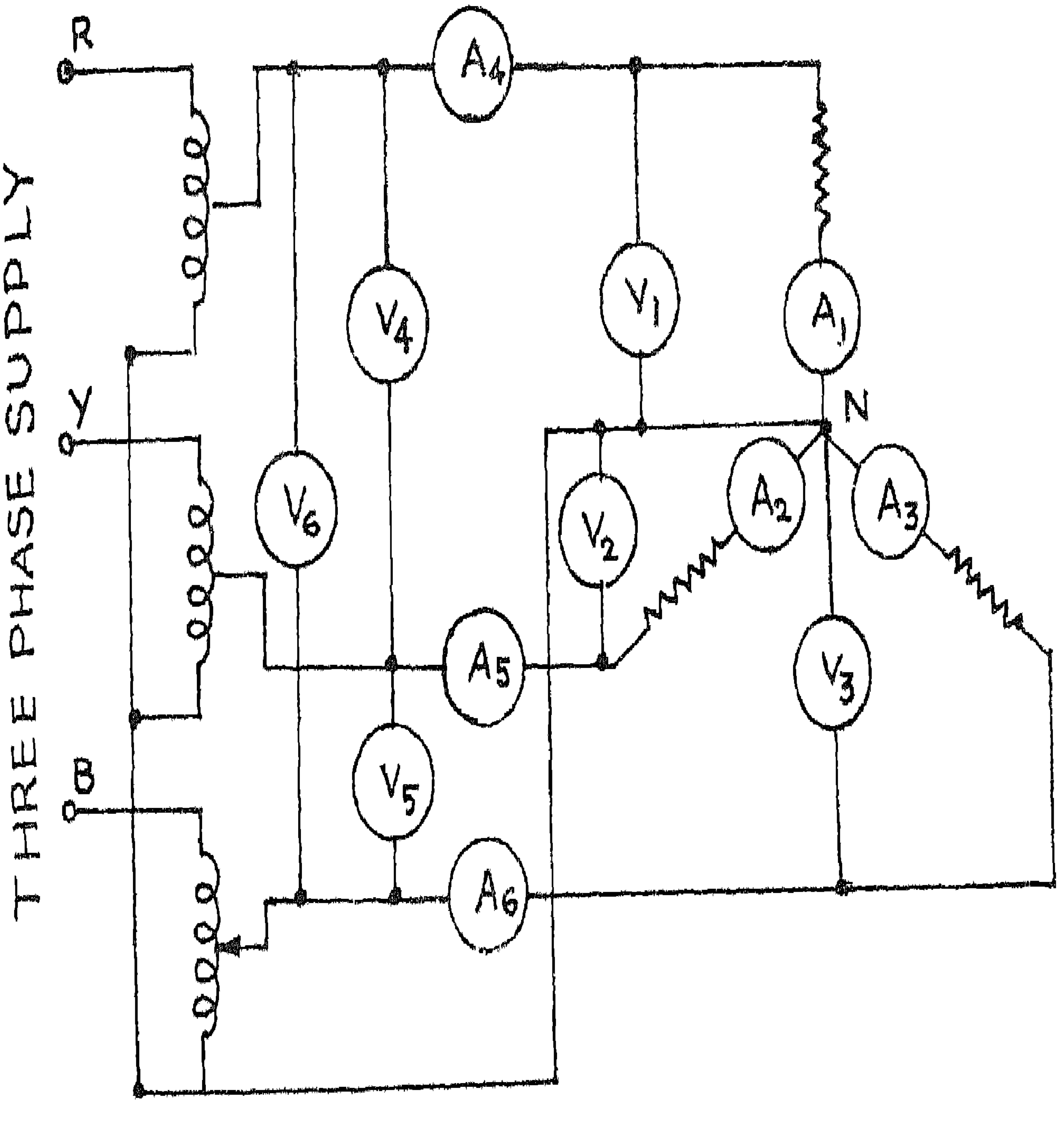


DELTA CONNECTION

FIG 18.4

CIRCUIT DIAGRAM

STAR CONNECTION



THREE PHASE
VARIAC

FIG.-18·5

CIRCUIT DIAGRAM

DELTA CONNECTION

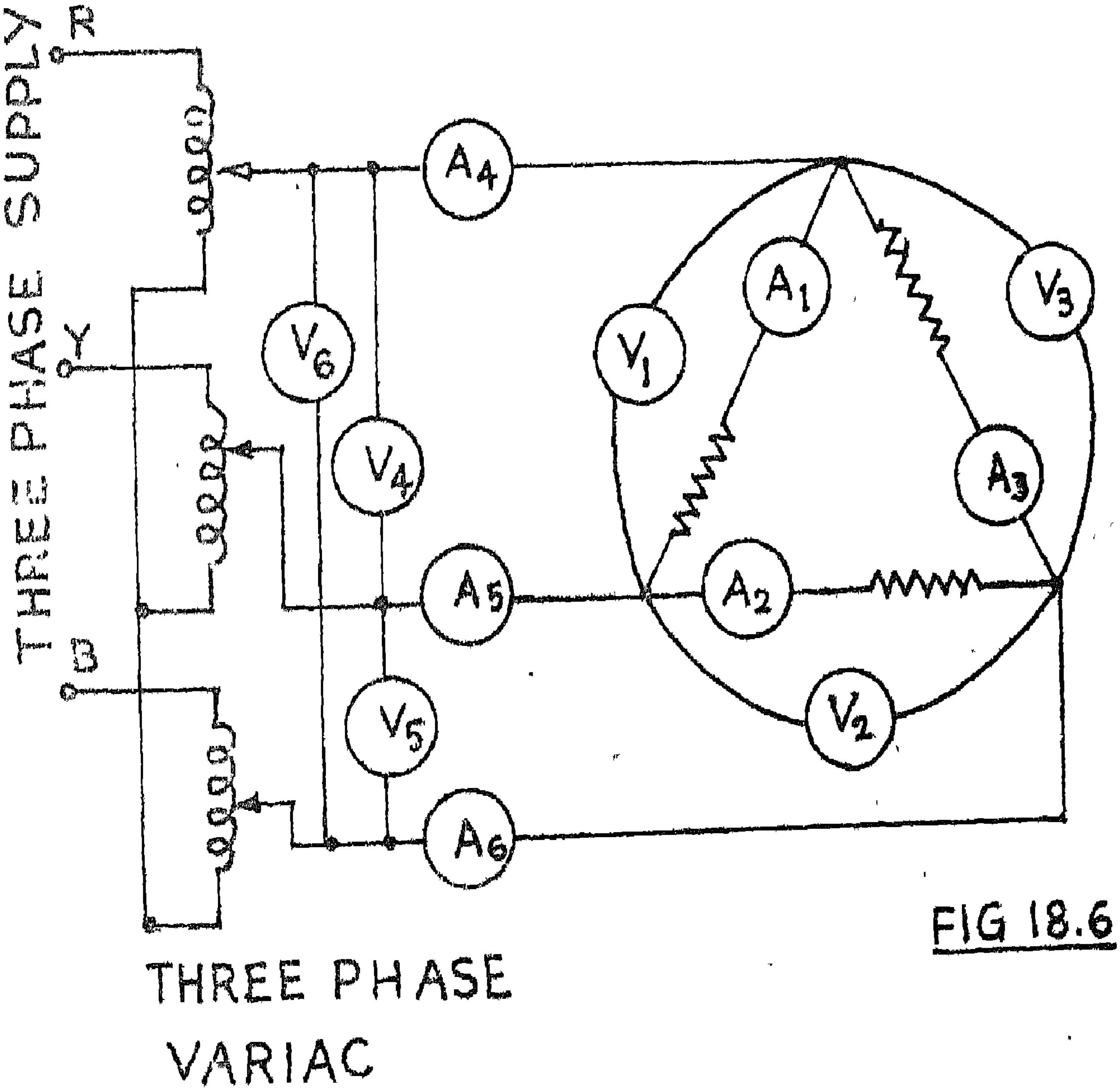


FIG 18.6

5. What is the basic difference between a balanced and unbalanced system ?

6. For your experiment, only one watt meter is available. Is it possible to compute the total power consumption ? If so, how ?

D. Reference:

Alternating current circuits by KERCHNER and CORCORAN.

APPENDIX- I.

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APPENDIX - II.

List of Equipments Materials required for Group I - 18 Experiments.

Vocational Area - Electrical Domestic Appliances and Rewinding for XI.

S.No.	Name of the equipment and Materials.	Type	Range/Rating	Number	Remarks
1	2	3	4	5	6
1.	Basic Tool Kit				
I	Insulated Screw Driver	15 cm.	-	1	(Tools in a Basic Tool Kit)
II	Insulated Screw Driver	12 cm	-	1	
III	Electrician plier	15 cm.	-	1	
IV	Electrician cutter	15 cm.	-	1	
V	Wire stripping Tool	-	-	1	
VI	Screw Driver with Neon Tester	-	-	1	
VII	Electrician Knife	-	-	1	
VIII	Nose plier	-	-	1	
IX	Fuse Wire	-	-	1 coil	
X	Insulation Tape	-	-	1 Roll	
XI	S[illegible]ering Iron	-	-	1	

1	2	3	4	5	6
	Equipments				
1.	Ammeter	M.C.	(0-500 M.A.)	4	
2.	Ammeter	M.C.	(0-1) Amp.	5	
3.	Ammeter	M.I.	(0-3) Amp.	1	
4.	Ammeter	M.I.	(0-5) Amp	1	
5.	Ammeter	M.C.	(0-5) Amp	1	
6.	Ammeter	M.I.	(0-10) Amp	9	
7.	Ammeter	M.I.	(0-15) Amp	3	
8.	Voltmeter	M.I.	(0-7.5) V	1	
9.	Voltmeter	M.C.	(0-7.5) V	2	
10.	Voltmeter	M.C.	(0-15) V	3	
11.	Voltmeter	M.I.	(0-50) V	1	
12.	Voltmeter	M.I.	(0-150) V	1	
13.	Voltmeter	M.I.	(0-250) V	3	
14.	Voltmeter	M.I.	(0-300) V	5	
15.	Voltmeter	M.I.	(0-500) V	6	
16.	Voltmeter	M.I.	(0-600) V	1	

17.	Voltmeterr	M. C.	(0-300) V	2
18.	Vacuum Tube Voltmeter	-	--	3
19.	Galvanometer	-	(100 micro amp-0-100 micro amp).	1
20.	Wattmeter	-	(0 - 300) V.DC (0 - 5) Amp. CC	1
21.	Wattmeter	-	(0 - 5 KW)	1
22.	Auto - Transformer	-	1 KVA, 230 V Input	1
23.	Auto - Transformer (Variac)	-	(0-250) V, 15 amp	1
24.	Auto Transformer	-	.0.5 KVA Single phase 230 V - 50 Hz.	2
25.	Transformer	-	230 V/12 V/6 V	1
26.	Auto Transformer (3 phase)	-	440 V 3 ph. 50 Hz.	1
27.	Resistor (casbon clay/ Vitrious type)	-	1 - ohm/10 W	1
28.	Resistor (casbon clay/ Vitrious type)	-	10-ohm/10 W	1
29.	Resistor (casbon clay/ Vitrious type)	-	20 - ohm/10 W	1
30.	Risistor (casbon clay/ Vitrious type	-	50 - ohm/10 W	1

31.	Resistor	-	100 - ohm/10 W	11
32.	Variable resistor	-	(0-10) ohm/10 A	1
33.	Variable Resistor	-	(0-100) ohm/2 Amp	2
34.	Rheostat	-	0- - 25 ohms/10W 5 Amp. 250V	2
35.	Inductor	-	0./H/1 Amp	3
36.	Inductor	-	100 mH	2
37.	Inductor (Chokecoil)	-	20 m H	1
38.	Capacitor	-	001 micro. F/1 Amp. 100 W	2
39.	Capacitor	-	1 micro F/1 amp.	2
40.	Capacitor	-	8 micro F/1 Amp	1
41.	Capacitor	-	100 micro F 5 Amp	1
42.	Capacitor	-	0.01 F.	1
43.	Slide Wire Bridge	Any type		1
44.	Thermister	Any available type		1
45.	Variable Frequency Generator	Oscillator	(0 - 10 KHZ)	2
43.	Cathode Ray Obcillograph	- -	- -	1

1	2	3	4	5	6
47.	Dry Cells	6 G Type	-	19	
48.	Clead Acid type-battery	12 V	12 A.H. Capacity	2	
49.	Clead Acid type battery	6 V	12 A.H. Capacity	2	
50.	Cotact Key	-	-	2	
51.	Standard Wire Garge	M.K.S. System		1	
52.	A three phase Induction Motor	440 V. 3 ph. 50 Hz.	1 Hp or 3 Hp or 5 Hp	1	
53.	Carbon Filament lamp	A. C.	100 W/230 V	1	
54.	Gas filled metal Filament lamp	A. C.	100 W/230 V	1	
55.	Small Bulb	D. C.	6 Volts	1	
56.	Thermometer	Centigrade	(0-360) degree	1	
57.	Joule's Calorimeter	-	-	1	
58.	Stop wateb	Second/minutes		1	
59.	Electric Bell	A. C.	230 V	1	
60.	Electric Bell	D. C.	6 V	1	
61.	Coil Winding Machine	-	-	1	
62.	Push Button Switch	-	-	2	

1	2	3	4	5	6
63.	Multimeter	(Standard type)		2	
64.	Hydrometer	-	-	1	
65.	Battery cell Tester	-	-	1	
	MATERIALS				
1.	U & T Shaped Transformer Stamping of suitable dimension		Tongue width $\frac{15''}{16}$ Thickness - 0.014"	150 Nos.	
2.	Supper Enamelled Copper	-	SWG - 23		
3.	S. E. Copper Wire		SWG - 19		
4.	Double Silk covered or Double cotton Wire		SWG - 17 and SWG - 15		
5.	Bobin	Suitable size			
6.	Empire Cloth				
7.	Leatheroid				
8.	Presspham				
9.	Mica Sheets				
10.	Dr. Beck Insulating Varnish				
11.	Empire Sheets				

1	2	3	4	5	6
12.	Both and Nuts	Required Number			
13.	Gasket Shellac (Air Drying)				
14.	Soldering lead				
15.	Soldering Flux				
16.	P.V.C. Wire				
17.	Iron Fillings				
18.	Test lamp				
N.B.	1) 220 V.A.C. (Single) Ø Supply 2) 440 A.C. (3 Ø) Supply		May be provided		

Dear Teacher/Pupil,

We are happy to place this Laboratory Manual at your disposal with the hope that it will help you conduct some of the practical works prescribed in the syllabus or practices necessary to gain thorough vocational expertise.

The Manual does not conform to the syllabus of any particular state but includes most of the important activities common in syllabi of different states. This is an experimental edition with ample scope for further improvement through feed-back from you. We solicit your active cooperaion for the improvement of the Manual.

After having used the Manual for a year or more, kindly read the appended questionnaire carefully and write down the answers precisely and exactly to the point. Kindly use additional sheet of paper if the space provided for is insufficient. The questionnaire may be mailed at the following address :

APPENDIX -III .

QUESTIONNAIRE FOR THE TEACHERS

LABORATORY MANUAL OF ______________________________

A. Name of the Teacher ______________________________
(In Block Letters)

B. Name and Postal address
of the Institution ______________________________
____
____

C. I) Qualification ______________________________

II) Teaching Experience ______________________________

III) Professional/Field/Industrial
experience ______________________________

1. Do the experimental activities covered in the Manual develop desired skills in the students?

Yes/No

2. List the experimental activities included in the Manual which do not figure in the syllabus.?

3. List the experimental activities included in the Manual which do not figure in the syllabus, but are vocationally important.

4. List the experimental activities prescribed in the syllabus but not covered in the Manual.

5. List the vocationally important experimental activities which are neither included in the Manual nor prescribed in the syllabus.

6. a) Does the relevant information given under every experimental activity furnish enough theoretical back ground of the activity,

Yes/No

b) If not, list the experiments where relevant information needs further modification.

Experiment No.	Portion	Type of modification needed.

7. a) Does the relevant information contain any factual errors or inaccuracies ?

Yes/No.

b) If any, give details

Experiment No.	Error/Inaccuracy	Should read as

8. Did you come across any expressions/sentences in the Manual which do not carry precise meaning or information? If Yes, then give the details.

Page No.	Expression/Sentence	Would be more appropriate.

9. Are the instructional objectives pertaining to each experimental activity rational ? If not, list down the irrational, irrelevant or vague ones.

Experiment No.	Irrational/Vague Objectives

10. Does accomplishment of the experiments result in realisation of the objectives.

Yes/No

11. Could you suggest any improvement in the presentation of the experiments along with your observations?

Experiment No.	Observations

12. Are the illustrations adequate?

Yes/No

13. Are there any inaccuracies in the illustrations/diagrammes given in the Manual? If yes, please point them out.

Illustration No.	Discrepancy/Inaccuracy

14. Please give your overall opinion about the Manual [illegible] may [illegible]eful in the effective improvement of futu[illegible]ions.

QUESTIONNAIRE FOR THE STUDENTS

LABORATORY MANUAL ON ____________________

A. Name of the Student (In Block letters) ____________________

B. Name and address of the school/college ____________________

C. Class ____________________

D. Medium of Instruction ____________________

1. List out the portions of the manual which you found difficult to understand and give reasons.

Experiment No.	Portion of the Text	Difficulty experienced.

2. Mention the places where you found the language difficult to understand.

Experiment No.	Page No.	Difficulty experienced.

3. Point out the figures/illustrations which do not help in under standing the topic/theme.

Illustration No.	Your observations/Difficulty experienced

4. Can you conduct the experiments your self with the help of this manual

Yes/No

If not, point out the portions of activity units which need further elaboration or explanation.

Experiment No.	Portion to be elaborated

5. Was the theoretical portion given in the Manual useful to you in understanding the why of the experiment?

Yes/No.

6. Do you now understand the scientific reasons behind the steps you have taken in conducting various experiments?

7. Yours overall candid opinion about the Manual.